Chapter 1
Private Water Wells

TABLES

FIGURES

INTRODUCTION

A reliable and safe water supply is important to every household, business, church, and institution. While public supplies are regulated by KDHE to ensure that they meet safe drinking water standards, the quality of private supplies is the sole responsibility of the owner and/or water user. There is no federal or Kansas law that regulates drinking water quality from private water wells. This chapter of the Environmental Health Handbook discusses in detail the basic principles for a reliable and safe water supply and includes an inspection protocol for new or existing wells.

The 1990 Census data showed Kansas has more than 109,000 private water supplies (mostly wells), which supply about 11 percent of the total housing units in the state. The most populous counties tend to have more private wells. Conversely, twenty-nine Kansas counties each have more than 1,000 private wells. Twenty eight counties, mostly in sparsely populated areas of the state, have fewer than 500 private drinking water wells each. In eastern Kansas, rural water districts cover much of the rural area, especially where there is no principal groundwater aquifer. Table I-1 summarizes private and public water supplies for each Kansas County.

Obtaining safe water from a private well should be relatively simple, but it requires carefully following some basic principles. Simply stated, safe water is most reliably obtained from a safe well. A safe well is one that meets the following conditions:

- Located away from potential contamination sources and out of possible pollutant pathways from both surface and groundwater flows.
- Meets current KDHE well construction standards.
- Annual check of condition and for damage, and complete the maintenance schedule.
- Well protection written plan has been prepared, is reviewed, and is followed.

WELL LOCATION

The well should be located in an area not subject to flooding, on a well-drained site, and as far removed and as far up-slope as practical from possible sources of contamination.

Microorganism Protection

A continuous blanket of moderate to well-drained soil in the area around the well generally provides good protection from microbiological contamination sources such as septic systems and animal wastes. The soil layers act as a good mechanical filter. Microbes in an aerated soil, aided by slow percolation through the soil, give reduction and die-off of microbiological pathogen contaminants. Thus, a 50-foot horizontal separation from a bacterial pollution source (K.A.R. 28-30-8) has usually been considered adequate to insure removal of pathogenic bacteria, viruses, protozoa, and cysts. However, additional separation will further reduce the risks of contamination.

When the total horizontal separation from pollution sources and the vertical separation distance to the groundwater aquifer is greater than 100 feet, additional protection is provided. The thickness of soil cover and depth to groundwater are usually greater in western Kansas. This greater travel distance, combined with lower rainfall and higher evaporation rates, produces much longer travel times for water that supplies the well. Thus, protection of groundwater from microbial

Table I-1. Public and Private Water Sytems in Kansas

COUNTY	TOTAL HOUSING UNITS	Units with Public Water System or Private Company		Units with Private Water Supplies	
		Number	Percent	Number	Percent
Allen	6,454	6,047	93.7	407	6.3
Anderson	3,514	3,127	89.0	387	11.0
Atchison	6,691	6,015	89.9	676	10.1
Barber	3,120	2,452	78.6	668	21.4
Barton	13,144	10,699	81.4	2,445	18.6
Bourbon	6,920	6,490	93.8	430	6.2
Brown	4,890	3,711	75.9	1,179	24.1
Butler	20,072	15,937	79.4	4,135	20.6
Chase	1,547	934	60.4	613	39.6
Chautauqua	2,249	1,711	76.1	538	23.9
Cherokee	9,428	8,390	89.0	1,038	11.0
Cheyenne	1,687	1,104	65.5	583	34.5
Clark	1,327	975	73.5	352	26.5
Clay	4,138	3,331	80.5	807	19.5
Cloud	5,198	4,371	84.1	827	15.9
Coffey	3,712	3,166	85.3	546	14.7
Comanche	1,256	889	70.8	367	29.2
Cowley	15,569	14,012	90.0	1,557	10.0
Crawford	16,526	16,311	98.7	215	1.3
Decatur	2,063	1,369	66.4	694	33.6
Dickinson	8,415	6,521	77.5	1,894	22.5
Doniphan	3,337	2,582	77.4	755	22.6
Douglas	31,782	30,574	96.2	1,208	3.8
Edwards	1,867	1,381	74.0	486	26.0
Elk	1,743	1,394	80.0	349	20.0
Ellis	11,115	9,725	87.5	1,390	12.5
Ellsworth	3,317	2,368	71.4	949	28.6
Finney	11,696	9,543	81.6	2,153	18.4
Ford	10,842	9,118	84.1	1,724	15.9
Franklin	8,926	7,792	87.3	1,134	12.7
Geary	11,952	11,007	92.1	945	7.9
Gove	1,494	984	65.9	510	34.1
Graham	1,753	1,153	65.8	600	34.2
Grant	2,599	1,941	74.7	658	25.3
Gray	2,114	1,401	66.3	713	33.7
Greeley	801	511	63.8	290	36.2
Greenwood	4,243	3,665	86.4	588	13.6
Hamilton	1,214	942	77.6	272	22.4
Harper	3,481	2,920	83.9	561	16.1
Harvey	12,290	10,655	86.7	1,635	13.3
Haskell	1,586	1,057	66.7	529	33.3
Hodgeman	1,022	531	52.0	491	48.0
Jackson	4,564	3,705	81.2	859	18.8
Jefferson	6,314	5,335	84.5	979	15.5
Jewell	2,409	1,845	76.6	564	23.4
Johnson	144,155	143,434	99.5	721	0.5
Kearny	1,561	1,145	73.4	416	26.6
Kingman	3,645	2,219	60.9	1,426	39.1
Kiowa	1,738	1,306	75.2	432	24.8
Labette	10,641	10,204	95.9	437	4.1
Lane	1,117	770	69.0	347	31.0
Leavenworth	21,264	19,328	90.9	1,936	9.1
Lincoln	1,864	1,258	67.5	606	32.5

Source: US Census Bureau, 1990 Housing Census Data

Table I-1 (contd). Public and Private Water Sytems in Kansas

COUNTY	TOTAL HOUSING UNITS	Units with Public Water System or Private Company		Units with Private Water Supplies	
		Number	Percent	Number	Percent
Linn	4,811	4,209	87.5	602	12.5
Logan	1,466	1,090	74.4	376	25.6
Lyon	14,346	13,413	93.5	933	6.5
Marion	5,659	4,051	71.6	1,608	28.4
Marshall	5,269	4,394	83.4	875	16.6
McPherson	10,941	8,982	82.1	1,959	17.9
Meade	2,049	1,518	74.1	531	25.9
Miami	8,971	7,912	88.2	1,059	11.8
Mitchell	3,359	3,100	92.3	259	7.7
Montgomery	17,920	16,534	94.5	986	5.5
Morris	3,149	1,602	50.9	1,547	49.1
Morton	1,515	1,151	76.0	364	24.0
Nemaha	4,319	3,602	83.4	717	16.6
Neosho	7,726	7,362	95.3	364	4.7
Ness	2,048	1,464	71.5	584	28.5
Norton	2,798	2,048	73.2	750	26.8
Osage	6,324	5,843	92.4	481	7.6
Osborne	2,496	1,981	79.4	654	20.6
Ottawa	2,591	1,842	71.1	749	28.9
Pawnee	3,412	2,599	76.2	813	23.8
Phillips	3,264	2,421	74.2	843	25.8
Pottawatomie	6,472	4,756	73.5	1,716	26.5
Pratt	4,620	3,520	76.2	1,100	23.8
Rawlins	1,744	994	57.0	750	43.0
Reno	26,607	19,981	75.1	6,626	24.9
Republic	3,283	2,652	80.8	631	19.2
Rice	4,868	3,748	77.0	1,120	23.0
Riley	22,868	20,695	90.5	2,173	9.5
Rooks	2,979	2,356	79.1	623	20.9
Rush	1,999	1,525	76.3	474	23.7
Russell	4,079	3,789	92.9	290	7.1
Saline	21,129	20,114	95.2	1,015	4.8
Scott	2,305	1,701	73.8	604	26.2
Sedgwick	170,159	155,355	91.3	14,804	8.7
Seward	7,572	6,875	90.8	697	9.2
Shawnee	68,991	67,749	98.2	1,242	1.8
Sheridan	1,324	752	56.8	572	43.2
Sherman	3,177	2,532	79.7	645	20.3
Smith	2,615	1,903	72.8	712	27.2
Stafford	2,666	1,583	59.4	1,083	40.6
Stanton	956	634	66.4	322	33.6
Stevens	2,116	1,606	75.9	510	24.1
Sumner	10,769	8,410	78.1	2,359	21.9
Thomas	3,534	2,611	73.9	923	26.1
Trego	1,851	1,258	68.0	593	32.0
Wabaunsee	2,853	1,640	57.5	1,213	42.5
Wallace	840	566	67.4	274	32.6
Washington	3,355	2,449	73.0	906	27.0
Wichita	1,190	767	64.5	423	35.5
Wilson	5,091	4,592	90.2	499	9.8
Woodson	2,199	1,794	81.6	405	18.4
Wyandotte	69,102	68,825	99.6	277	0.4
State Totals	1,044,112	934,205	89.5	109,656	10.5

Source: US Census Bureau 1990 Housing Census contamination is usually substantially greater in western than in eastern Kansas for the same horizontal separation unless there is poor well construction. When the soil blanket is thin, poorly-drained, shallow to rock, very coarse, or combinations of these conditions occur, more rapid groundwater recharge rates are likely. The more quickly water moves through the soil to groundwater, the greater the risk of microbes being carried to the aquifer. These conditions more commonly occur in eastern Kansas, meaning that greater separation distances are needed to provide the same measure of protection as in western Kansas. Additionally, groundwater movement through joints, cracks, and solution channels of rock aquifers in eastern Kansas is much more rapid. This also reduces the protection provided by horizontal separation.

Minimum separation distances regulated by K.A.R. 28-30-8 and K.A.R. 28-5-2 are presented in Table I-2. The plan view in Figure I-1 shows the well location as well as the required and recommended separation distances from sources of contamination. These distances should be adequate to protect from microorganism contamination, however greater distances provide added protection. Much greater separation distances are necessary to protect from other pollution sources (inorganic and organic chemicals).

TABLE I-2. Minimum and Recommended Separation Distances from Private Wells

Potential Source of Pollution	**Separation Distances (in feet)**	
	Minimum Required [1]	Recommended [2]
Sealed sewer line (cast iron, tight line, etc.)	10	50
Unsealed sewer lines	50	> 400
Septic tanks (watertight)	50	> 100
Lateral lines and septic absorption field	50	> 400
Pit privies	50	> 400
Stables, livestock pens, lagoons and manure piles	50	> 400
Streams, lakes and ponds	50	> 100
Fertilizer and fuel storage (above or below ground)	50	> 400
Seepage pits (prohibited after May, 1996)	50	> 400
All other wastewater systems	50	> 100
Property line	25	> 50
Public water supply sources (i. e., wells) [3]	100	> 100
Building/structure (termite treatment) [4]	50	> 100
Pesticide storage, mixing and disposal repeated use areas	50	> 400

[1] *Required by K.A.R. 28-30-8.*

[2] *Separation distances that help assure more adequate protection from contaminants other than bacteria.*

[3] *From Policies, General Consideration and Design Requirements for Public Water Supply Systems in Kansas.*

[4] *Required when injecting liquid pesticide, see manufacturers label. These distances do not assure contamination will not reach well.*

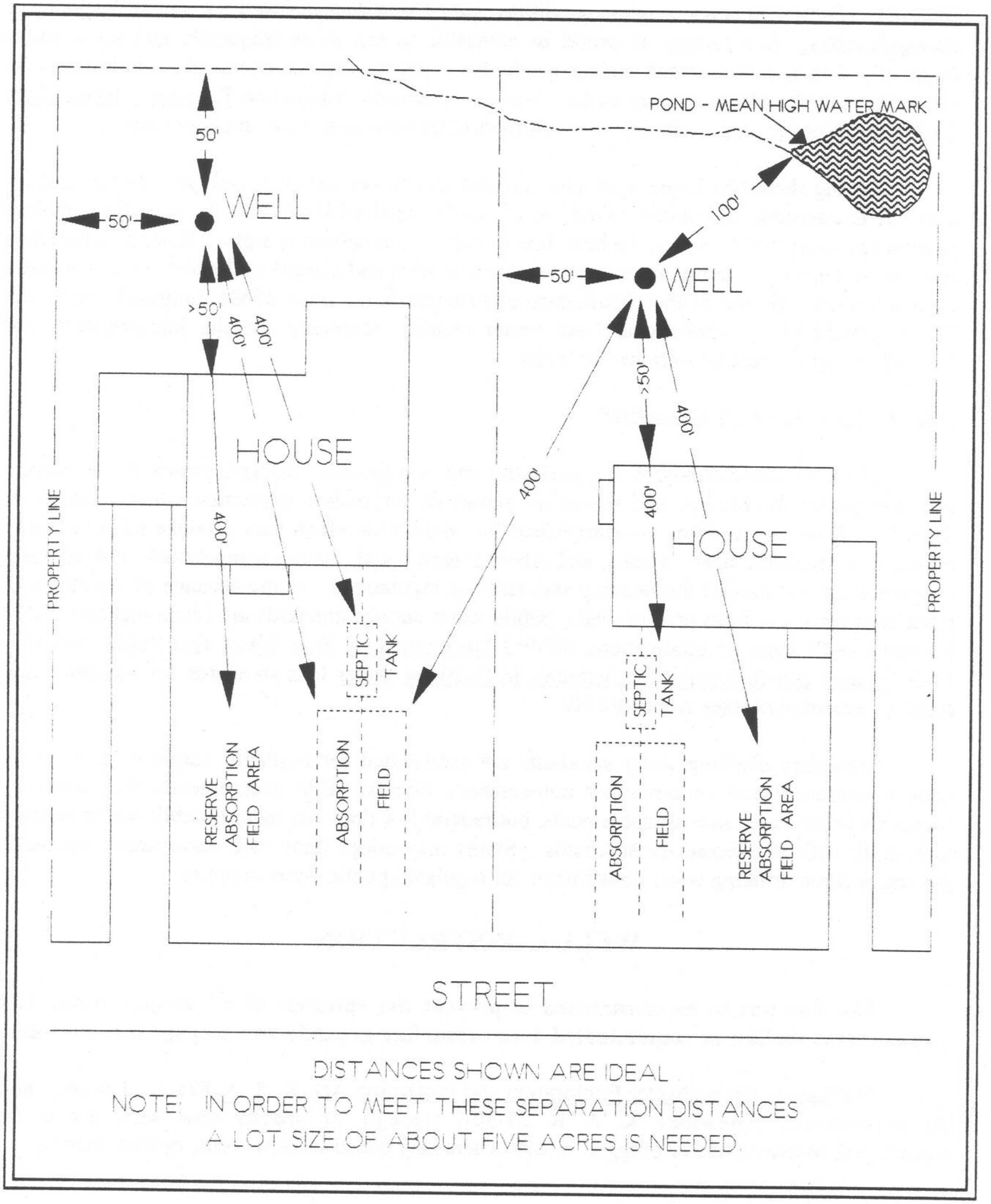


Figure I-1. Site Features Showing Minimum and Recommended Separation Distances

A sanitarian, extension agent or other qualified person should be called upon to assist in siting a new well location. A protocol to evaluate a new well site or existing well and a report form to assist in collecting the necessary data is included at the end of this chapter.

Protection from Other Contaminants

Protecting wells from contaminants other than microorganisms involves management at the surface and separation distances greater than 50 feet. *The Farmstead Well Study*, conducted by the Kansas State University and Kansas Department of Health and Environment in 1986-87, found 28 percent of the wells with nitrate levels above the safe drinking water standard of 10 mg/L. Other inorganic chemicals above the standard were found in an additional 10 percent of wells. Pesticides were detected in 8 percent of the wells but were above the EPA drinking water standard in only 1 percent of wells.

Protection of well water from sources of contamination other than microorganisms requires much more careful planning. For instance, nitrate, like most negatively charged inorganic constituents (known as anions) moves freely through the soil. It is dissolved in water and is carried along as the water percolates through the soil to the groundwater and moves in the aquifer. The most active removal mechanisms for nitrate are: a) careful management of nitrogen sources at the surface, b) removal by plants as water percolates through the root zone, and c) denitrification in shallow, poorly aerated layers. Once nitrate reaches groundwater, there is virtually no mechanism for removal except lateral movement with groundwater to a well or reappearance at the surface through springs.

Some organic and inorganic chemicals, both natural and man-made, are adsorbed by the exchange capacity of clay and organic matter in the soil. However, excessive repeated applications, dumping, and spills can exceed the soil's capacity to remove these contaminants. Because most organics are at least partly dissolved in water, if they are not removed they can be carried to groundwater.

The effluent from a properly designed and operated wastewater system still contains large amounts of dissolved nutrients, some of which eventually may reach groundwater. The effluent also contains some chemical contaminants and viruses which are capable of traveling long distances when they reach groundwater, especially in jointed and channeled rock. The required minimum separation distance for wastewater systems is 50 feet from private water supplies and 100 feet from public water supplies. However, to minimize possible health hazards and pollution potential of wastewater systems it is good policy to locate them as far as possible from drinking water supplies and surface water.

The type and number of wastewater systems and other sources of pollution in the vicinity of a well gives an indication of the potential for contamination of the groundwater supplying that well. The well construction, volume of water pumped, and the well draw-down are also extremely important as they determine the distance and speed with which pollution may travel. Usually pollution will be minimized with increased separation distance and groundwater travel time.

Cone of Depression

A well in regular use causes groundwater to flow towards the pumping well. The withdrawal of water from the well by pumping causes the water level in the well to be lower than the static, nonpumping, water table. This lowers the pressure (creates a vacuum) in the area surrounding the well which in turn causes the groundwater level to decline around the well. This drop in the level of the water table around the well is called the cone of depression. The distance away from the well that the cone of depression extends is the radius of influence. Any source of contamination that reaches the groundwater within the radius of influence can be drawn toward the well. See diagram of cone of depression for a pumping well in Figure I-2.

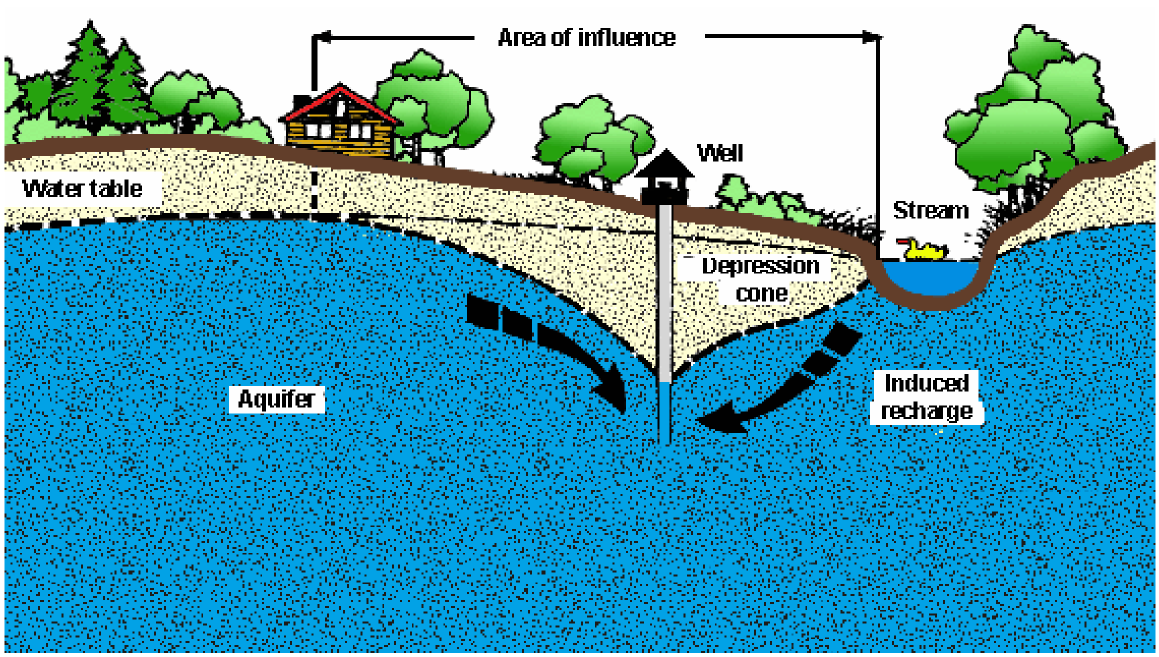


Figure I-2. Cone of Depression for a Pumping Well

Example of cone of depression. The elevation at the well is 1,200 feet, the original water table is 1,080 feet, the water level is 1,050 feet when the well is pumped, and the radius of influence is 400 feet. A pollution source located 350 feet from the well can potentially contaminate the well if the contamination moves down to groundwater, elevation about 1,078 feet, within the cone of depression. Thus, the protection of a well from pollution sources is not just a matter of surface separation distance. Rather it is a combination of surface separation, elevation of the pollution sources and well, radius of influence (cone of depression) of the pumping well, and groundwater flow direction and gradient.

Wells, in areas of fractured limestone formations near the ground surface or where solution channels are known to exist in the rock formations, should be separated by much greater distances from pollution sources. Special precautions should be taken to prevent shallow subsurface seepage from entering the well. The surface ground slope should be away from the well. Local sanitary and environmental codes may require more stringent standards than state regulations and should always be consulted before sitting a new well.

When factors that might influence well contamination were evaluated in Phase 2 of the *Farmstead Well Study*, separation distance was the strongest contributor to contamination. The greater the distance of the source of contamination from the well, the less chance there is of contamination affecting water produced by the well. Based on this study, a minimum 200 foot separation distance from sources of contamination is recommended to provide adequate protection of wells for both inorganic and organic contaminants.

Locating a New Well

Careful evaluation of all potential sources of contamination is essential when siting the location of a well. Many potential sources are shown in Figure I-1 for a modern farmstead. Contamination sources include fertilizer and pesticide handling, storage, mixing and clean-up areas; above and below ground fuel storage tanks; and mechanic/maintenance shop areas where solvents and degreasers are used.

A good approach to safely locate a well is to draw a 200 foot radius circle around each of the potential sources of contamination and then locate the well outside of all circles. Be sure the well is located up-gradient in groundwater flow direction from these sources. Figure I-3 illustrates a typical rural development with the preferred location of pollution sources associated with house, yard, and septic system in relation to the location of the well.

A study during 1994-1995 sponsored by the Centers for Disease Control found total coliform bacteria present in 51 percent of private drinking water wells in Kansas. *E. coli* was present in 18 percent of these wells. Approximately 80 percent of the wells included in this study did not meet either location guidelines or current construction standards.

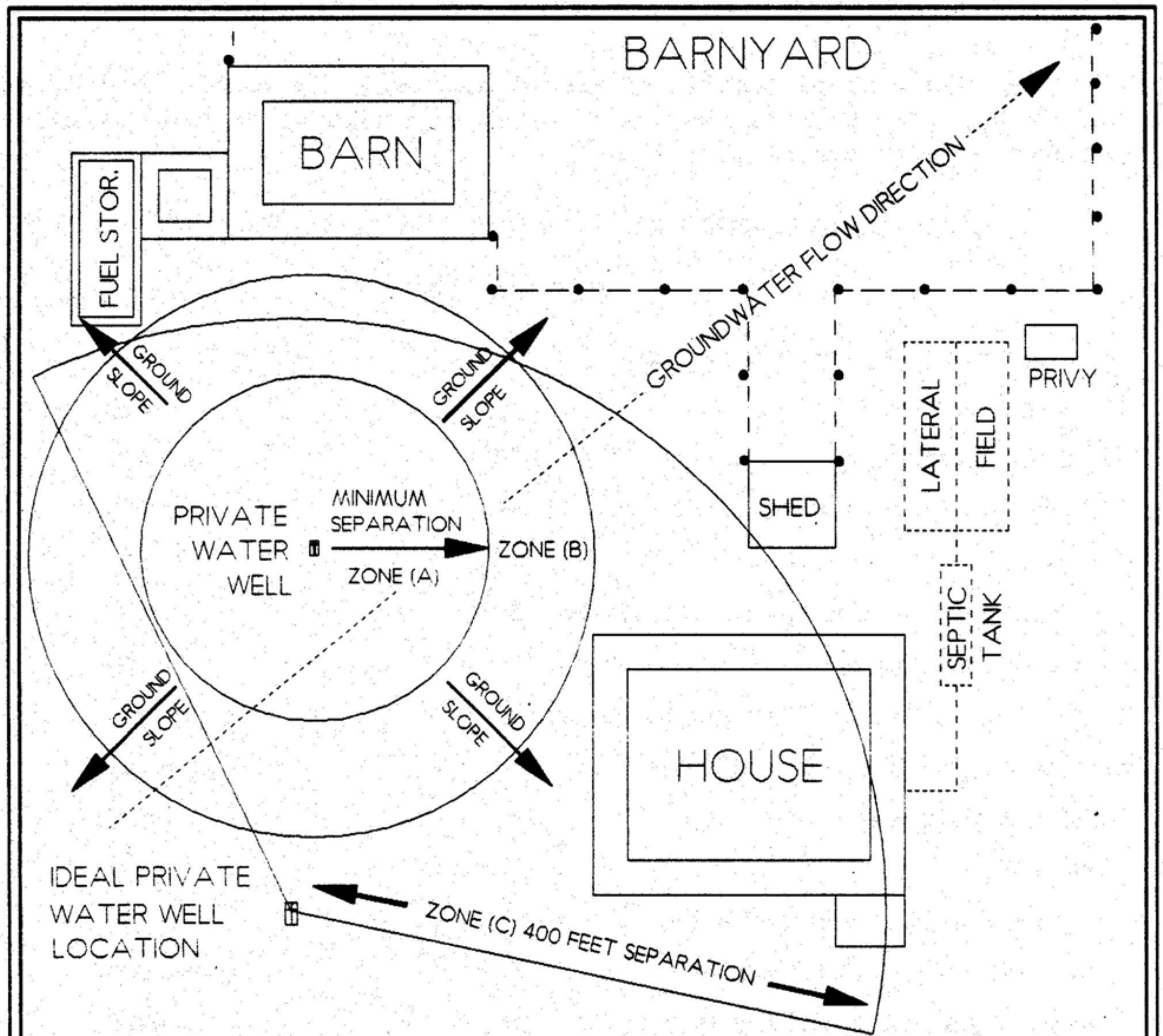
See Protocol: Well Evaluation for a New Site or Existing Private Well at the end of this chapter.

WELL CONSTRUCTION

To supply good water, the well construction must prevent the entrance of all surface water and shallow or deep groundwater seepage into the well except at screened sections. Approved grout must restore the seal around the casing at the surface and through all confining layers.

The ***Kansas Groundwater Exploration and Protection Act***, also called the *Water Well Construction Act*, K.S.A. 82a-1201 et seq., and the implemented regulations, K.A.R. 28-30-1 et seq., specify how wells are to be constructed, reconstructed, and plugged. They set minimum standards for well construction and reconstruction, and specify materials used in constructing or reconstructing water wells.

Well construction and reconstruction requires a licensed Kansas Water Well Contractor. However, landowners may construct new wells, modify existing wells, and plug wells located on their own property without being licensed by KDHE. Landowners must comply with all requirements of the law and regulations including the filing of a Water Well Record (form WWC-5) with KDHE as mandated by law.



ZONE (A): REQUIRED SEPARATION AT LEAST 50 FT. FROM SEWERS, SEPTIC TANK SYSTEMS, PRIVIES, BARNYARDS, FUEL, FERTILIZER STORAGE, BUILDINGS, ETC. NOT LESS THAN 25' FROM PROPERTY LINE (50' OR MORE RECOMMENDED) ALL SURFACE DRAINAGE MUST BE AWAY FROM THE WELL.

ZONE (B): RECOMMENDED 100 FT. (OR MORE) SEPARATION FROM SOURCES OF CONTAMINATION. (SEE TABLE 2)

ZONE (C): IDEAL PRIVATE WATER WELL LOCATION 400 FEET OR MORE FROM SOURCES OF CONTAMINATION. (SEE TABLE 2)

Figure I-3. Good Well Location and Separation Distances for a Farmstead

Numerous methods have been developed for construction of water wells. These include digging, driving, boring, and drilling. In recent decades, practically all new wells in Kansas are drilled or driven. Recommendations and requirements for using these two methods as well as procedures for reconstructing or upgrading dug wells are briefly discussed here.

Drilled Wells

A drilled well is constructed with a drilling machine using rotary, percussion, or jetting tools. The hole is drilled into or through the water-bearing formation(s) and a casing and screen are inserted into the bore hole. New PVC, wrought iron, steel or other KDHE approved materials, in clean and serviceable condition, shall be used to case the well.

Construction details for unconsolidated (sand and gravel) and consolidated (rock) drilled wells are shown in Figures I-4 and I-5. For purposes of illustration different grout materials are shown.

Driven Wells

Driven well construction is limited to areas of unconsolidated aquifers and where the water-bearing strata lie at comparatively shallow depths. Driven wells are most often used only where the water table is less than 20 feet below ground surface. Driven wells can not be used where there are intervening formations of rock, hard and dense layers, or boulders that would interfere with the driving of the pipe.

Driven wells are properly constructed by drilling and casing at least the upper 10 feet of the well or to the water table if more than 10 feet. This provides for easy placement of the required protective grout around the outer casing placed in the bore hole. The outer well casing must meet the casing requirements of K.A.R. 28-30-1, et seq. The well is completed by driving a water-tight pipe (normally steel) that is fitted with a drive point and a well screen into the water-bearing formation below the water table to the desired depth, sufficient for continuous pumping. Construction details for a driven well are shown in Figure I-6.

Dug Wells

Construction of dug wells has been illegal since the Well Construction Act was passed in 1975. Existing dug wells should be abandoned and properly plugged or reconstructed to meet the requirements of this act and accompanying regulations. Reconstruction of dug wells to meet current well construction standards and thus reduce potential of contamination is generally not cost effective.

Well Casing

To insure adequate protection of the aquifer(s) supplying the well, the casing must exclude surface water and water from undesirable subsurface strata. All wells must have durable, watertight casing from at least one foot above finished ground surface (recommend at least one foot above the elevation of the 100-year flood) to the top of the producing zone(s) of the aquifer. The watertight casing shall extend at least at least 5 feet into the first clay or shale layer or a minimum of 20 feet below the finished ground surface. The casing shall be clean and serviceable and of a type to assure that it remains watertight for the useful life of the well (usually at least 40 years). Used, reclaimed, rejected, or contaminated pipe shall not be used for casing any well.

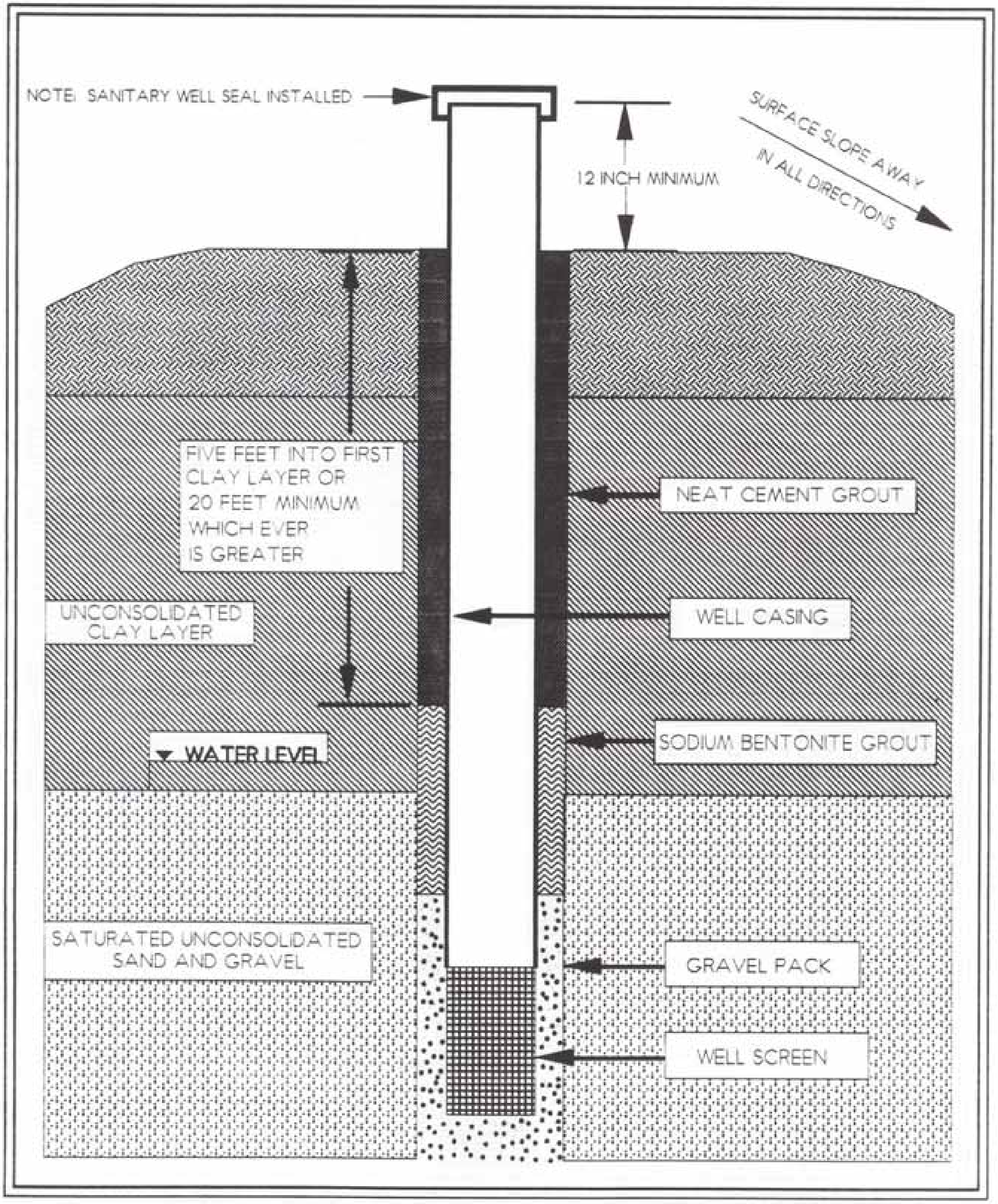


Figure I-4. Construction of A Drilled Well in an Unconsolidated Formation

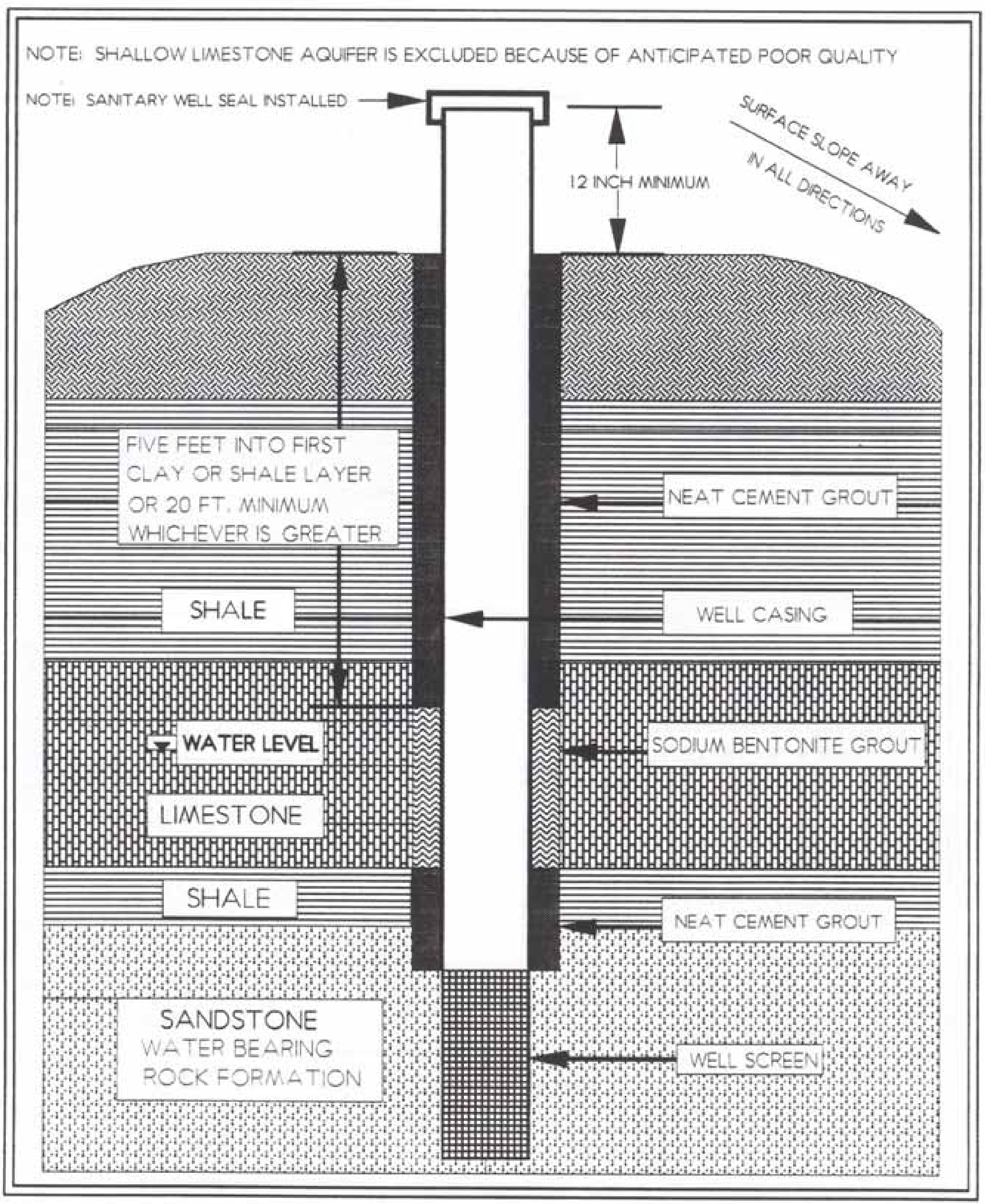


Figure I-5. Construction of A Drilled Well in a Consolidated Rock Formation

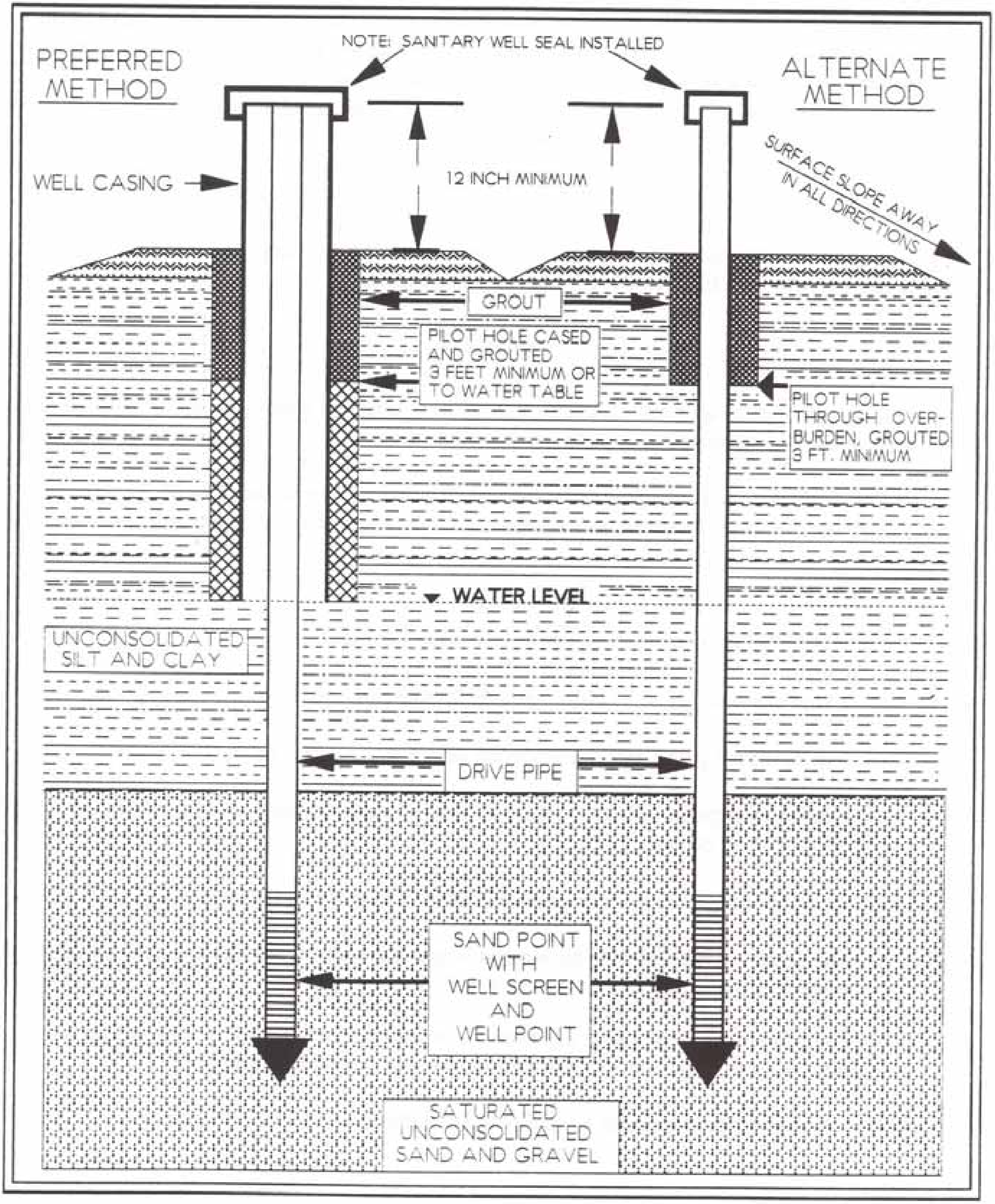


Figure I-6. Construction of A Driven Well

Groundwater producing zones that are known or suspected to contain natural or man-made pollutants must also be cased and sealed off during construction of the well to prevent the movement of the polluted or undesirable groundwater to either overlying or underlying fresh groundwater zones.

All water well casing must be approved by KDHE. Plastic pipe must meet standards of the National Sanitation Foundation (NSF) or American Society for Testing and Materials (ASTM) and bear the stamp of approval PW (potable water), DW (drinking water) or WELL CASING. It is important that all connections (joints) be watertight where two sections of well casing are joined. Concrete pipe, vitrified clay tile, and similar type materials are **not approved** for well casing unless special permission is granted by KDHE as provided in the Appeals Clause in K.A.R. 28-30-9.

The casing must be of sufficient inside diameter (ID) to easily accommodate the maximum outside diameter (OD) of the pumping equipment to be installed in the well. Most small drilled wells serving farmsteads, homes, and businesses are cased with five inch ID casing or larger. Casing of this diameter will accommodate most submersible turbine pumps, deep well jet pumps, reciprocating pumps, and numerous other types of shallow well pumps in sizes commonly used to supply water for household purposes.

The well casing must be watertight from the screened intake to at least twelve inches above finished ground surface. No casing shall be cut off below the ground surface except to install a pitless well unit. No holes shall penetrate the watertight well casing except to install a pitless adapter and this penetration must be finished watertight.

Well Grouting

The space between the casing and the bore hole must be grouted to restore aquifer separation by preventing water movement through this space. The diameter of the bore hole must be at least three inches greater than the maximum outside diameter of the well casing to facilitate the placement of grout around the casing throughout the required intervals. Adequately grouted wells protect the well and aquifer from contamination by preventing the mixing of surface water or water from different aquifer layers through the bore hole.

All well casing must be grouted to a depth of 20 feet or more below the finished ground surface. When the first clay or shale layer is deeper than 20 feet from ground surface, then the grouted interval must extend at least five feet into the clay or shale layer. The grouting requirement may be modified to meet local conditions (i.e. groundwater is encountered at less than the 20-foot minimum depth) when prior approval is obtained from KDHE.

For example, while drilling the bore hole a clay layer is found at 34 feet below the ground surface. At 57 feet the clay layer changes to sand and gravel that contains potable groundwater. The placement of the well casing would be then from the top of the aquifer (57 feet) to at least one foot above finished ground surface. The well casing is grouted into the bore hole from the 39 foot depth to finished ground surface or to a depth just below the deepest frost line if a pitless adapter or pitless unit is installed. The construction of a concrete slab around the well casing is optional and may also help provide a good seal around the casing in addition to providing a strong clean work platform for servicing the well.

It is common for wells that penetrate multiple water bearing layers to be designed to obtain groundwater from two or more separate aquifers. In such wells, the casing interval between the aquifers must be grouted into the bore hole to maintain aquifer separation within the borehole even though two or more aquifers are communicating through the well's screens. This requirement is mandated to assure that if one of the aquifers becomes unusable it can be blocked off from the other aquifer with packers or sealed off with a blank casing liner or abandoned and plugged to protect the usable aquifer from the undesirable aquifer.

Well Screen and Gravel Pack

The well screen should be factory slotted and installed as designed to prevent gavel pack or aquifer materials from entering the well. Well screens should be made of corrosion-resistant materials. In most cases, screens that are fabricated from an alloy of copper, tin, silicon, and manganese are satisfactory. In waters containing large amounts of sulfate or detectable hydrogen sulfide, a stainless steel or polyvinyl chloride (PVC) plastic screen should be used to enhance corrosion protection. The choice of the well screen slot size (mesh size) is dependent on the particle size of the aquifer material and the gravel pack used. By examining samples of the aquifer materials collected when the well is drilled, most well screen manufacturers can determine the screen slot size and gravel pack design needed to prevent fines from entering.

Fine, silty sand cannot normally be prevented from entering the well by use of a well screen alone. In this case, a specific gravel pack design is critical to control the continuing entrance of fines into the well. Washed, graded gravel pack disinfected with at least 200 parts per million (ppm) chlorine solution is placed around the well screen to prevent entrance of undesirable fine material. This chlorine concentration is produced by 51 ounces of 5¼ percent chlorine bleach, 27 ounces of 10 percent liquid chlorine bleach, or 4 ounces of dry 65 percent dry chlorine per 100 gallons of water.

When the aquifer contains large quantities of fine material such as very fine sand or silt, in addition to good well screen and gravel pack design, thorough development of the well is essential. Development helps retard the movement of very fine sand and silt into the well. Sand and silt accelerate wear on the pump and can accumulate in the bottom of the well which may prevent proper cooling of the pump motor and eventual motor failure. Sediment can accumulate in plumbing, pressure tank, and water heater and also cause turbidity in the water.

Well Development

Well development is a specialized part of well construction and should be done by a Kansas Licensed Water Well Contractor who has the necessary equipment. It is recommended that all newly constructed or reconstructed wells be developed by one of the procedures discussed here. Think of development as dislodging and washing fine material out of the aquifer adjacent to the well. Some of these fines are introduced during well drilling.

Well development is accomplished by using a bailer, high pressure jetting, over-pumping (a rate exceeding the well capacity to deliver water), and other methods that physically force the well water back and forth through the well screen and gravel pack. The action of water moving in and out of the well screen, gravel pack, and adjacent aquifer removes the majority of the very fine sand and silt in the aquifer within the immediate vicinity of the well bore. The larger particles of the aquifer are left in place, next to the gravel pack, which effectively helps hold back the very fine sand and silt that is farther away from the gravel pack.

A bailer (a hollow open top cylinder pipe from 5 to 20 feet long with an opening and flapper valve in the bottom) is lowered into the well. The flapper valve opens when the bailer is lowered into the well and then close when it reaches the bottom. Repeatedly lowering and raising the bailer surges the well, pushes and pulls water in and out of the well screen, gravel pack, and adjacent aquifer. The very fine sand and silt is dislodged, suspended, and flushed into the casing. The bailer is drawn to the surface with flapper valve closed and its contents, water with sediment, is discharged to waste. Well development by bailing is continued until the water withdrawn is mostly clear of sediment.

The over-pumping development method involves placing a high capacity pump (without the normal check valve) and pump column pipe near the bottom of the well. When the pump is turned on, the water is lifted and discharged at the surface to waste. After the pump has been discharged for a period of time, it is turned off and the water inside the pump column is forced by gravity into the well and back through screen. This washes or “back-flushes” the fine materials from around the well screen. This cycle is repeated many times, with the length of the discharge time increased each time. Pumping continues until the water discharged to waste is clear.

High pressure jetting development involves using a tool with nozzles that drives high pressure water into the screen while the tool is lowered, raised, and rotated throughout the well screen area. Water that meets drinking water standards and that has been disinfected is delivered by pump to the nozzle jets. After jetting, the tool is removed and a bailer or pump is used to remove the dislodged sediments. Alternate jetting followed by sediment removal is repeated in sequence until the well water becomes clear.

Sanitary Well Seal

The top of every well casing must be fitted with a KDHE approved, water-tight sanitary seal to prevent entry of contaminants including water, animals, insects, or other pollutants. If the pump is not installed immediately, a permanent cap can be installed on the casing. This seal or cap prevents any contamination from accidentally entering the well and minimizes chances of vandalism. The sanitary seal is available for use with a variety of pumps, piping, and well casing diameters. Examples are illustrated in Figure I-7.

See Protocol: Well Evaluation for a New Site or Existing Private Well at the end of this chapter.

DISINFECTION OF WELL

The well casing, pump, wiring, and piping system should be thoroughly disinfected following well construction, development, repairs, pump installation, and annually as part of a preventive maintenance program.

When wells are constructed or reconstructed and pumps and piping are installed or repaired, microbiological contamination often results. All wells used for human consumption or food

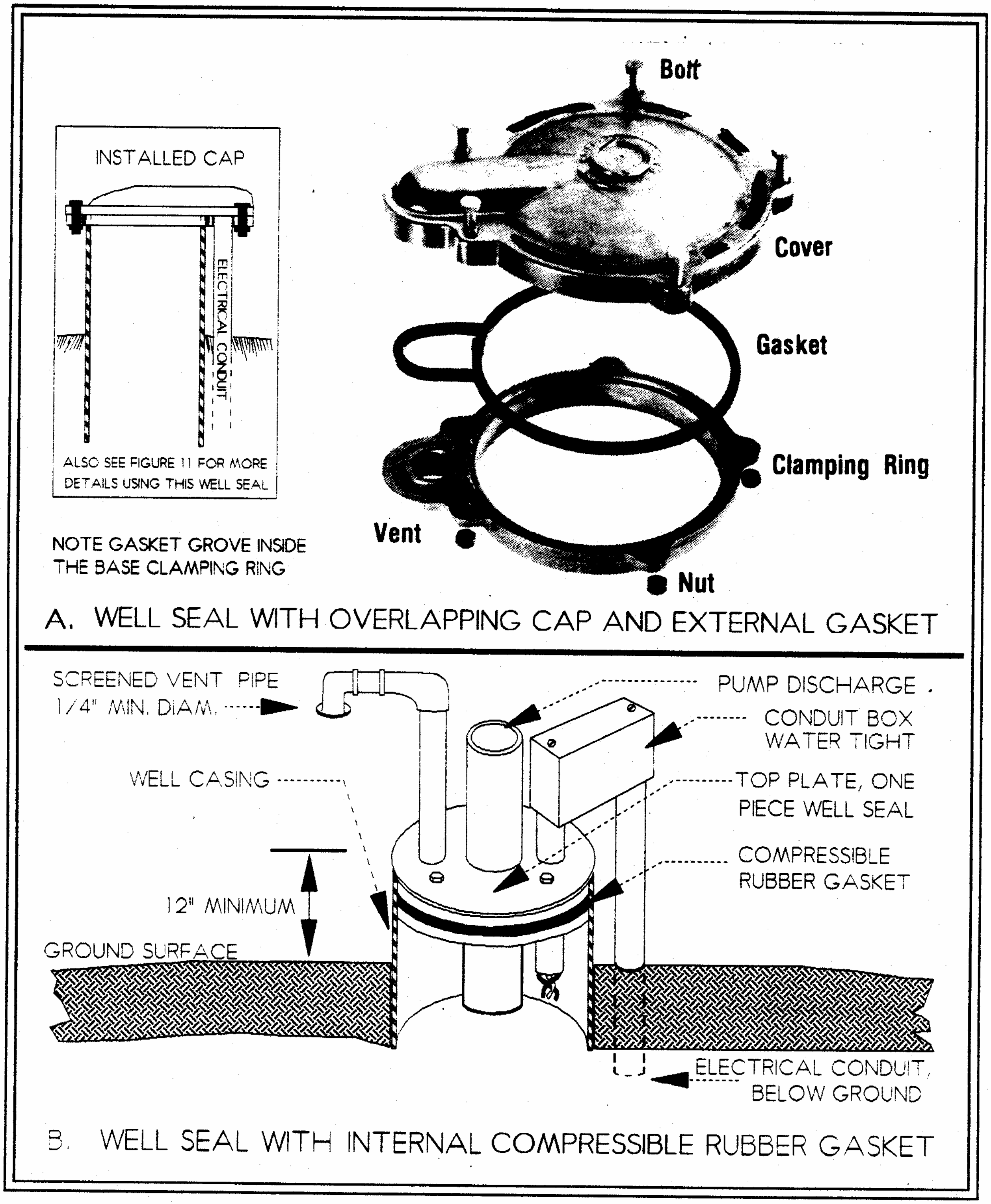


Figure I-7. Sanitary Well Seals

processing must be thoroughly disinfected before its first use in compliance with K.A.R. 28-30-10. An effective and economical method for disinfecting water wells is through the use of a high strength chlorine solution. Common laundry bleach contains a 5¼ or 6 percent solution of sodium hypochlorite is readily available and suitable to make the chlorine solution.

The recommended chlorine dosage for disinfection of existing wells, reconstructed wells, pump replacement or pump or well repairs is 500 mg/L or ppm (a gallon of laundry bleach for each 100 gallons of water) in the well and plumbing system. For disinfection of new wells, a dosage of 100 mg/L or ppm (one gallon of laundry bleach for each 500 gallons of water) is recommended. The recommended procedure for disinfecting water wells is found in Appendix A and in K-State Research and Extension publication *Shock Chlorination for Private Water Systems*, MF-911.

Following disinfection of the well and its appurtenances (plumbing), a sample of water should be collected after 7 days for bacteriological analysis. Prior to sampling the water, a test for free chlorine should be made. If chlorine is present, bacterial analysis should be postponed until the water is free of chlorine. If the bacteriological analysis indicates the water is still contaminated, the disinfection procedure should be repeated.

In rare cases, after careful investigation fails to reveal any defects in location or construction of the well and total coliform bacteria continue to be present, installation of equipment that provides continuous disinfection many be necessary.

Note: continuous disinfection is not a reliable replacement for proper well location and construction.

WELL PUMPS

The well should be provided with a pump selected for the application. The pressure and volume relationship that defines the pump curve is the primary factor in choosing the correct pump for the application. The pump should be installed in a manner that will prevent contamination from entering the well. A wide variety of pump equipment is available for lifting and pressurizing water from wells. The two most common devices, power pumps and hand pumps, are discussed in the following sections:

Power Pumps

Two types of power pumping equipment are commonly installed today on private water supply wells; the submersible turbine type pump and the jet type pump. Examples of power pump equipment and the important sanitary features governing their installation are shown in Figures I-8 and I-9. For more information on pumps refer to the EPA *Manual of Individual and Non-Public Water Supply Systems* or the Midwest Plan Service *Private Water Systems Handbook.* See references for complete citations.

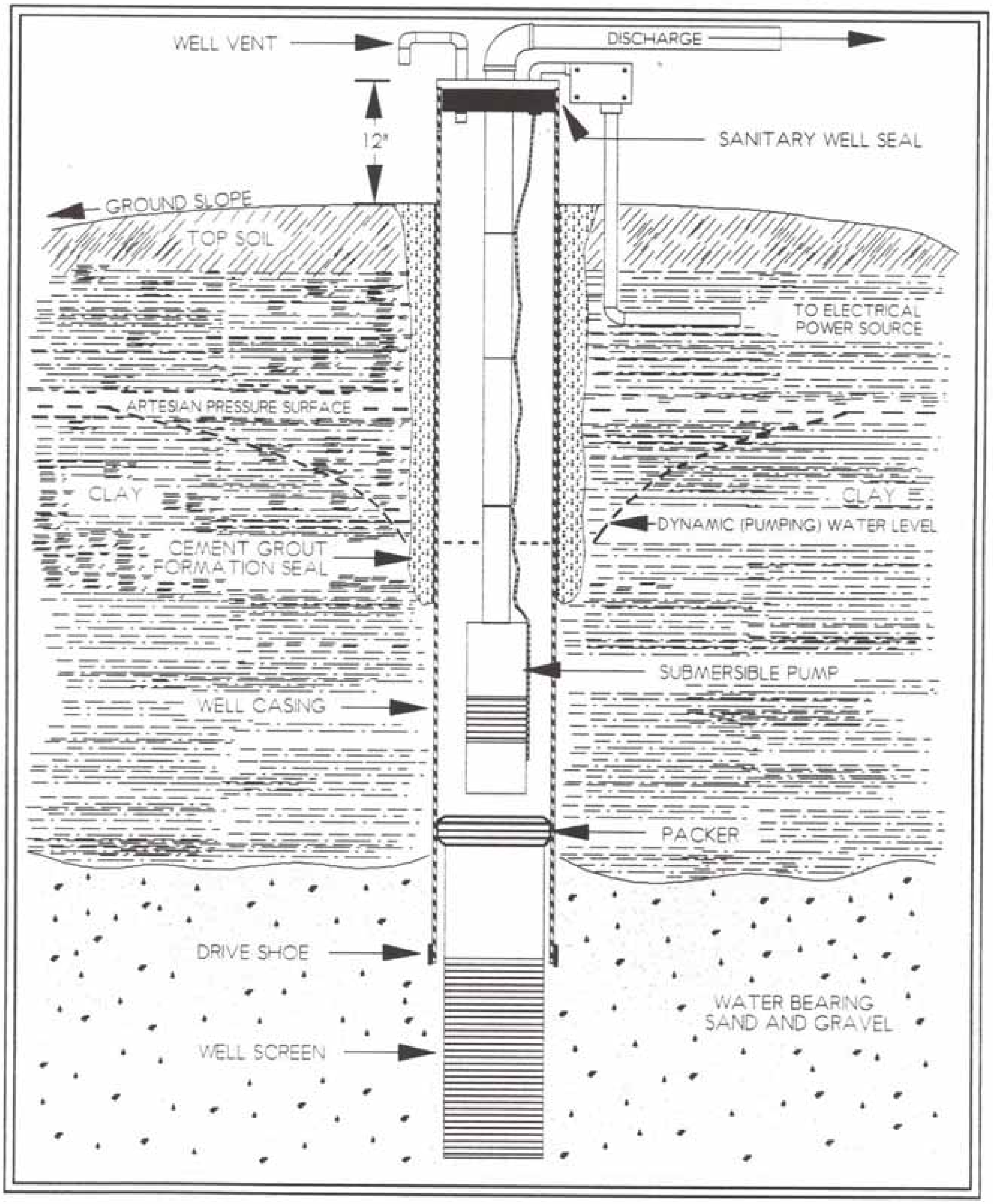


Figure I-8. Submersible Pump Components

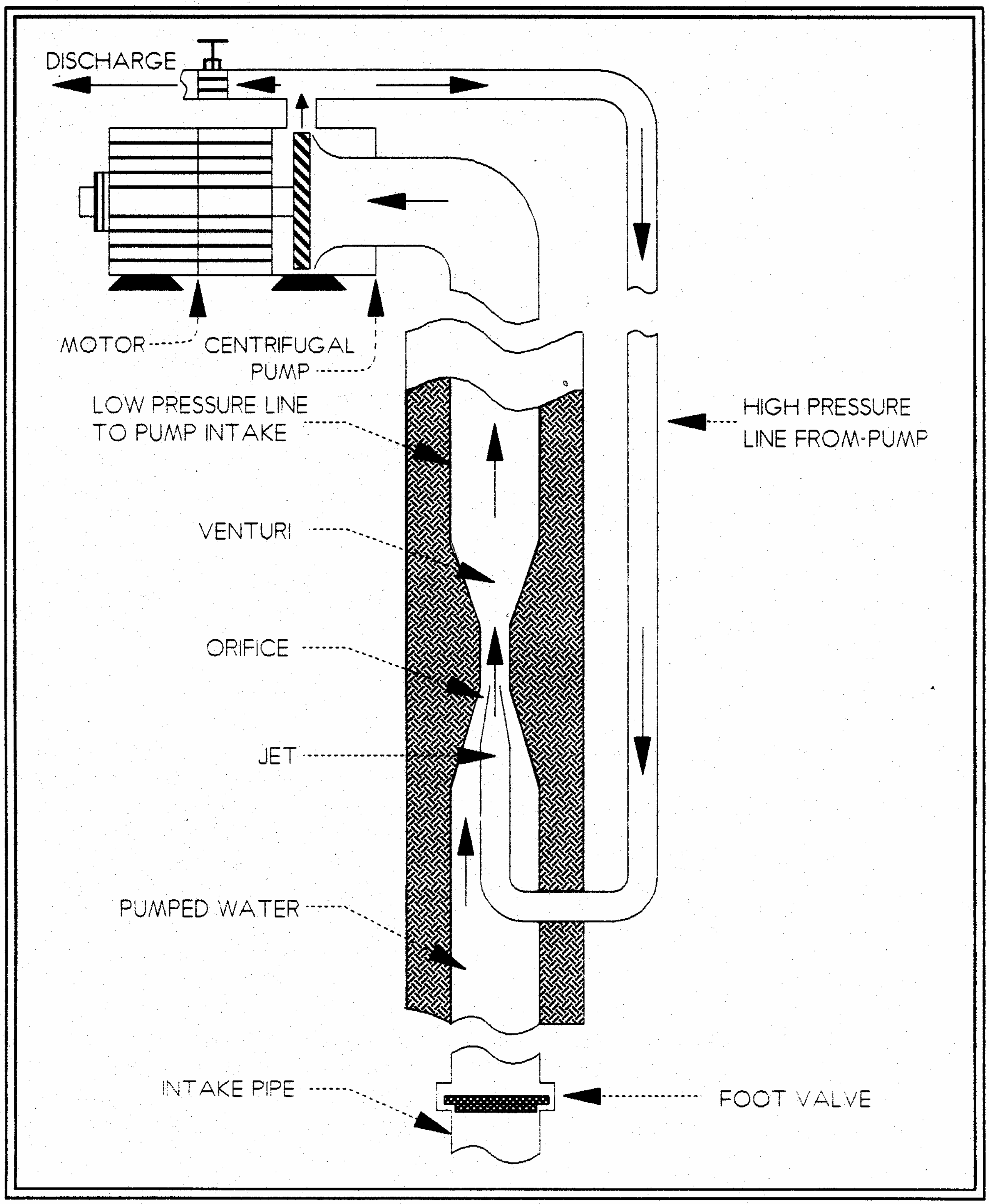


Figure I-9. Twin Tube Jet Pump Components for Deep Well

Hand Pumps

The basic sanitary requirements for hand pumps are:

1. A solid, one piece, recessed type cast iron pump base, cast or threaded to the pump column, must be provided.
2. The top of the pump must be provided with a stuffing box or gland that forms a seal for the pump sucker rod.
3. The pump spout must be closed and directed downward.
4. A flange and gasket must be provided for attaching the pump base to the well casing.
5. The pump cylinder should be located below the static water level in the well so that priming of the pump is not necessary.
6. Adequate overhead clearance is essential to permit removal of pump rods, pump column pipe and pump cylinder for maintenance, repairs or replacement.

The recommended design for a hand pump installation is shown in Figure I-10.

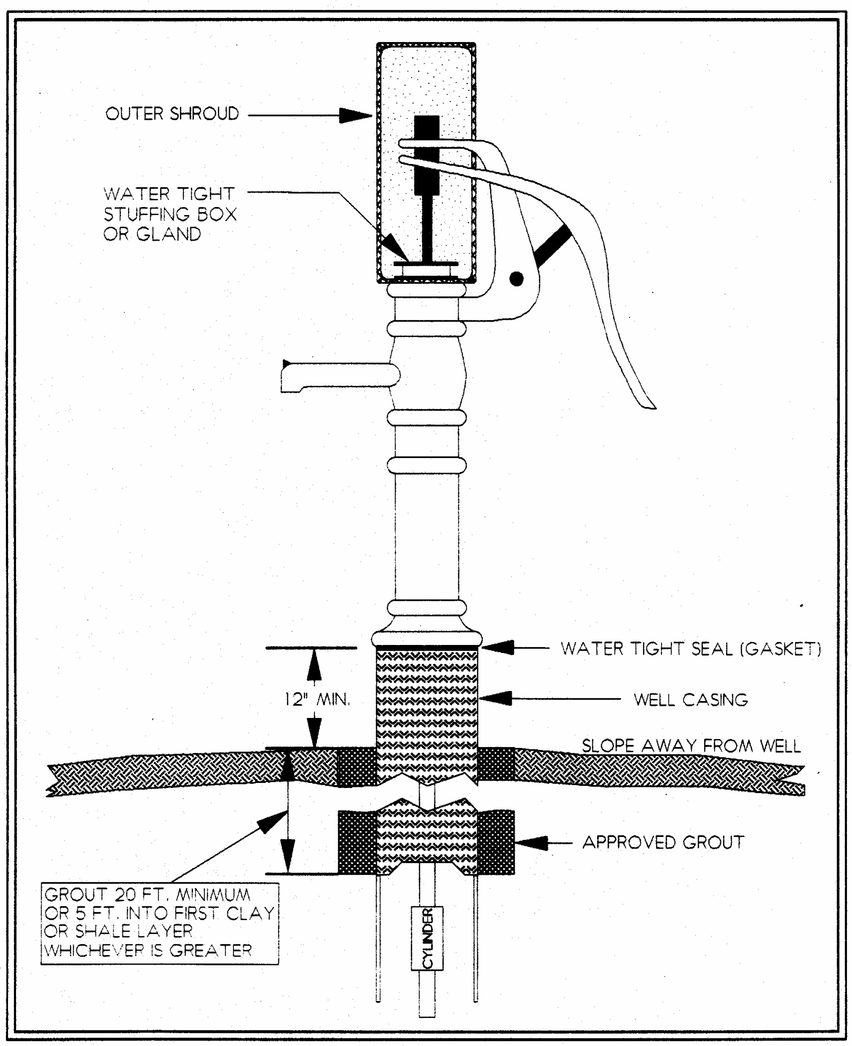


Figure I-10. Sanitary Hand Pump Components

FREEZE PROTECTION

Well installations require freeze protection for the piping and in some cases also the pump and pressure tank. Two feasible freeze protection options are pitless installations with the pump located in an area not subject to freezing, such as a basement or well pit at least 2 feet from the well, or an insulated pump house with supplemental heat. A submersible pump installed in the well is the most common pump type except for shallow wells. In the past, wells were often put in pits, basements, garages, and crawl spaces, or buried beneath the ground surface for freeze protection. These techniques and locations are all prohibited by state regulation K.A.R. 28-30-6(o) implemented in 1975 because of the high potential for contamination.

Well Pump House

A pump house is a structure built over well on a concrete floor to protect equipment from freezing and damage. The size of the pump house depends on how much equipment, the size of the equipment and how much space is needed to remove, replace or repair the equipment placed there. Allow adequate room to work comfortably while repairing or replacing. If you plan to install a pump, pressure tank, and disinfection equipment, the building will need to be larger than if only the pump will be housed there. Dimension~~s~~ of a small pump house would be four feet long by four feet wide by seven feet tall. A larger pump house could be eight feet wide by eight feet long by seven feet tall. The roof should always be built so it can easily be removed or have a hatch that can be opened to enable removal of the pump column. The complete structure should be watertight, vermin and insect proof, and insulated to retain heat in the winter. A well work-over pulling unit is often used to pull pump rods, pump column pipe, submersible pumps, and other lengthy equipment placed inside the well.

In order to install as much insulation as practical, R30 if possible, the walls and ceiling should be 10 inches thick for fiberglass and 5½ inches thick for rigid foam. All walls should be solid on the interior and exterior and trimmed or sealed where they meet. All vents should be fine mesh screened to reduce the likelihood of insect entry. The door should be well insulated, weather stripped, and lockable. The pump house floor should be constructed of reinforced concrete at least four inches thick and sloped away in all directions from the well casing or suction pipe. Because the danger of electrical shock is greater with a wet floor, care should be exercised when installing electrical equipment in the pump house to be sure that the floor is well-drained and dry.

Supplemental heat can be provided by installing a thermostatically controlled heater, usually electric heat tape near the floor around piping, or an alternate heat source. A ground fault circuit interrupter (GFCI) should be used for all circuits in areas of water. All electrical wiring should be placed in vermin proof conduit.

Continuous chlorination of private well supplies is not normally required but provisions for installation of such equipment should be included in the pump house design. Figure I-11 shows recommended construction for the pump house. The pump house should not be used to store any material that could contaminate water including pesticides, paint, products that contain petrochemicals, or other chemicals or products.

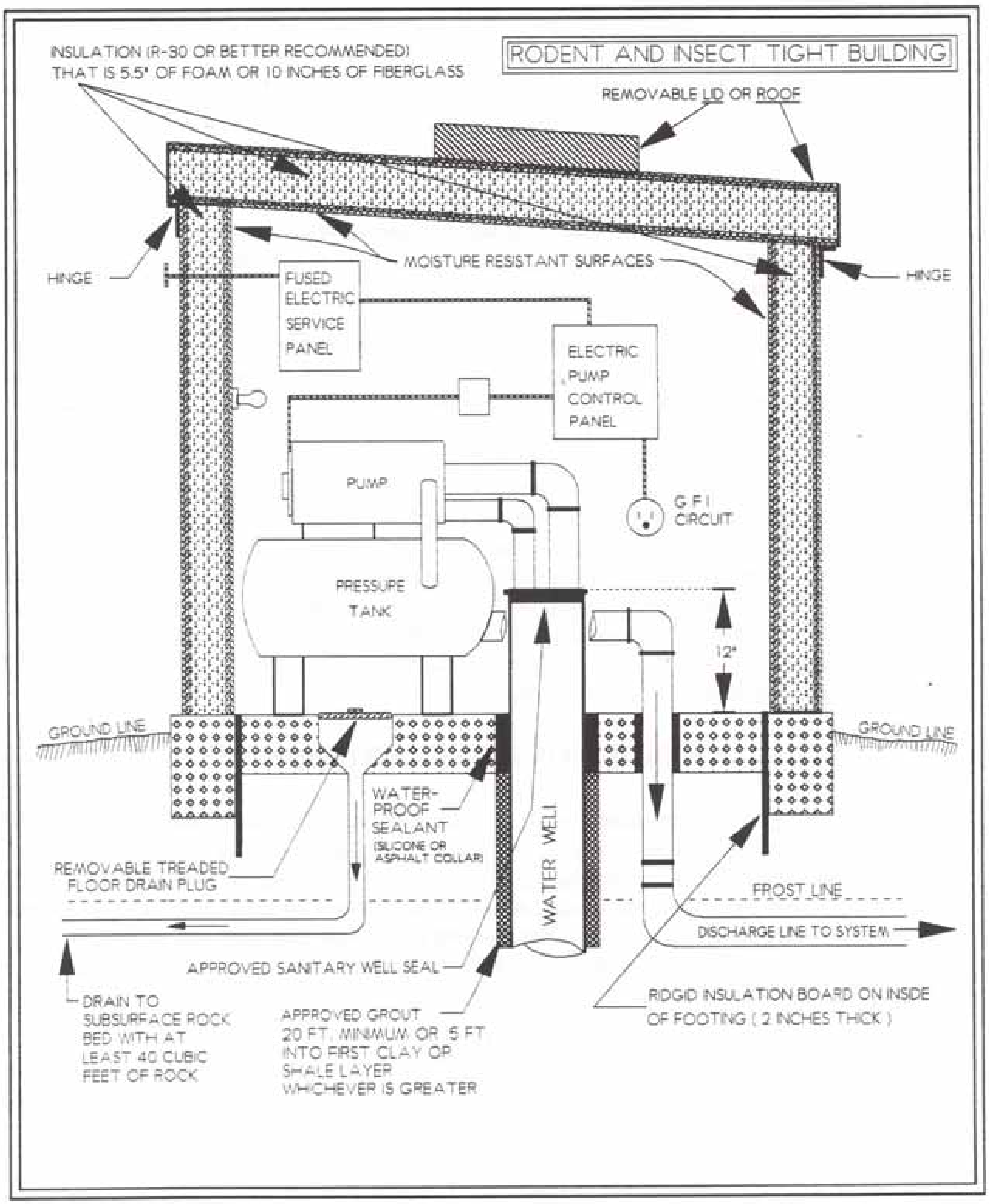


Figure I-11. Typical Pump House Components

Pitless Installations

Figure I-12 illustrates a typical pitless well device installation. The device (called a pitless well adapter or pitless unit) is often used in conjunction with a submersible pump to assure freeze protection for water lines. A basement may be a suitable option for locating the pump and pressure tank. A 50 foot separation distance of the well from buildings is required because of potential

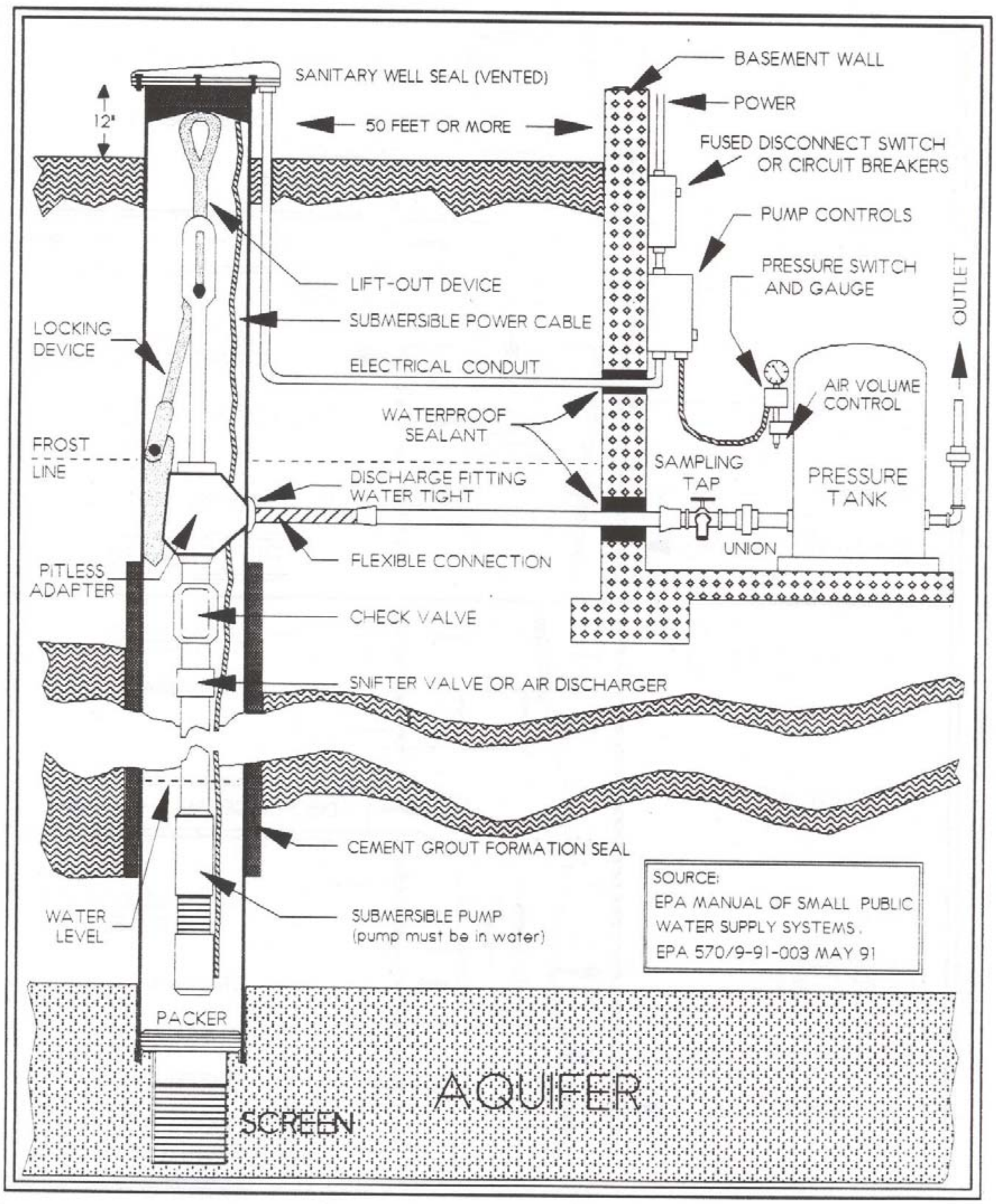


Figure I-12. Typical Pitless Well Device

contamination from termite treatment. This separation of the well applies when the pump and pressure tank are located in the basement. The design of a pitless well unit and a pitless well adapter are shown in Figure I-13. A well in a pit has been illegal for new construction since the Well Construction Act was adopted in 1975. A pump pit can still be used but must be located at least 2 feet away from the water well.

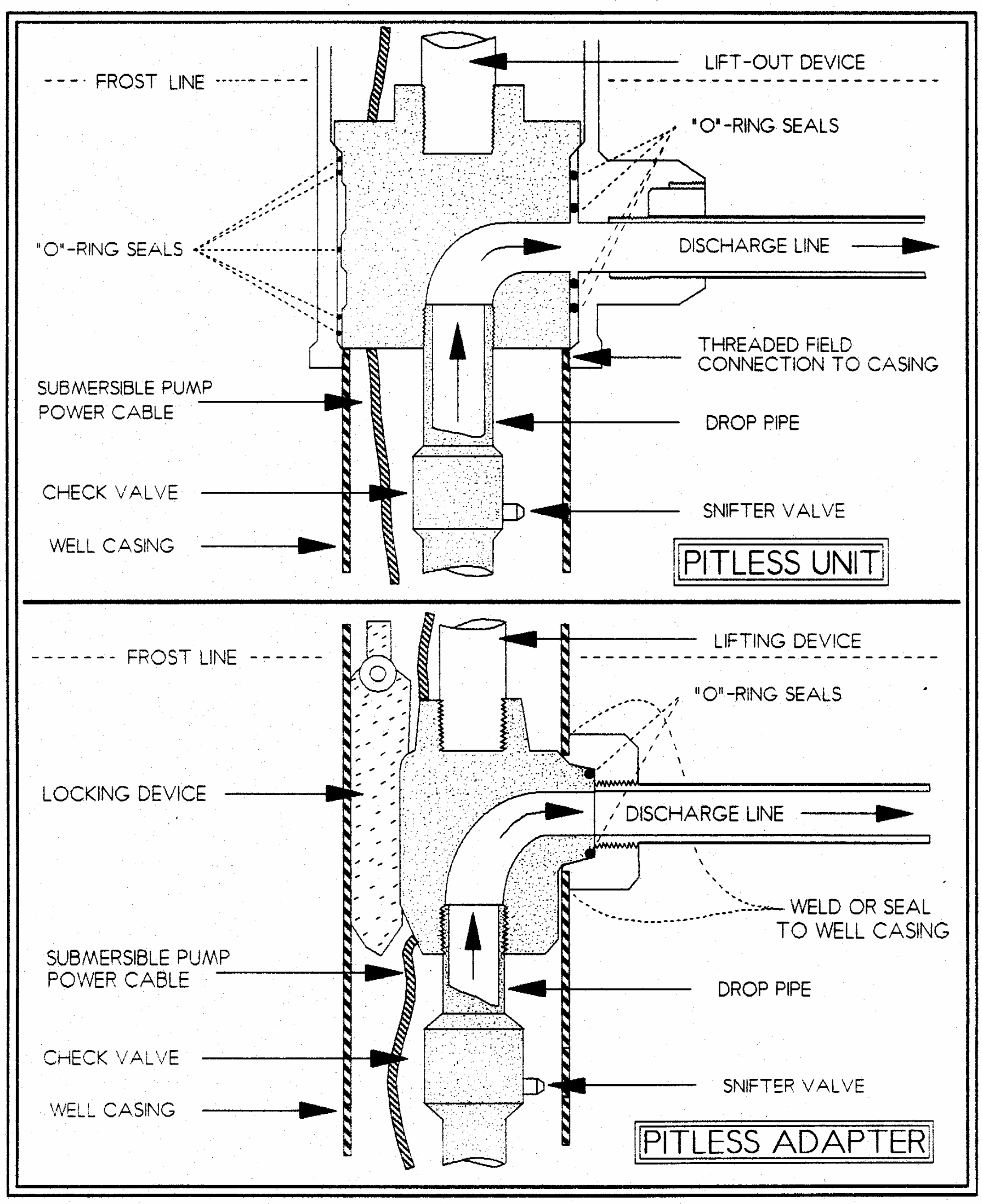


Figure I-13. Design of Typical Pitless Unit and Pitless Adapter.

WELL MAINTENANCE

The first concern is always that the location meets recommended separation distances between the well and sources of contamination as shown in Table I-2. Location is the most important factor for protection of water quality. Second is the quality of well construction which is of concern primarily when the well is initially drilled. However, well components deteriorate over time, can be damaged, or may be removed and not correctly reinstalled that means the well may no longer meet the construction standards and thus would be unsafe. Well maintenance is the important action needed to help assure that wells continue to be safe for supplying safe water.

In addition to good well location and construction that meets current well standards, regular maintenance helps ensure that the well continues to be a safe source of drinking water. A well that is not maintained can not be expected to reliably produce safe water. Recommended annual well maintenance includes: checking the well casing for leaks, checking for a secure and watertight well seal, assuring that the ground surface slopes away from the well, shock chlorination of the well and water system, and a verifying water test is free of coliform bacteria.

A checklist, recommended for an annual well maintenance procedure is presented in Table I-3.

Table I-3. Private Well 12-Point Maintenance Check

Do each year:

Check that the well casing is free of cracks or other leaks from the water table to at least 1 foot above the ground surface or highest flood level whichever is greater.

Check that the sanitary seal is a KDHE-approved type and is secure and watertight.

Make sure the ground slopes away from the well for at least 15 feet in all directions.

Shock chlorinate the well and water system.

Test coliform bacteria, nitrate, pH, and total dissolved solids and file the results with other records and information about the well.

Always do:

Have a licensed well driller (or a landowner who knows requirements) do all work on the well and casing and be sure well meets all current KDHE minimum construction standards.

Find and fix the cause of any change in water color, odor, or taste. Shock chlorinate the well and water system following any service on the system.

Maintain 50 feet (100 ft preferred) of open space between the well and any buildings, waste system, parked vehicle, equipment, compost, or other possible contamination source.

Store chemicals such as fertilizer, pesticides, oil, fuel or paint at least 100 feet down slope.

Prevent backflow and backsiphonage by maintaining an air gap above the container you are filling, or by using an adequate backflow prevention device.

Shock chlorinate the well after any service work on the pump, well, or water system.

Plug all abandoned wells and wells not used in the last 2 years following state regulations or upgrade them to current standards. Plug all unused cesspools, septic tanks, and other holes.

Note: See Extension bulletins in references at the end of the chapter for additional information.

Finally, every well needs a wellhead protection plan to assure continuing protection of water quality, especially for those wells being used for drinking water. The wellhead protection plan indicates site vulnerability to groundwater contamination and rates the risk of activities within 500 feet of the well. For the plan to have any benefit, it must be followed and updated by the landowner or user. With many problems of poor private well water quality in Kansas, it is in the owners' interest to take steps to protect their own wells so they can have safe water.

Water Testing

Remember: No Federal or Kansas law regulates the quality of drinking water from private water supplies. The owner or user is responsible for the quality of water from a private well.

After the annual maintenance check is done, a water test is recommended for coliform bacteria, nitrate, pH, and total dissolved solids concentration. Water testing confirms the water safety after all efforts have been made to be sure the well is safe. When coliform bacteria is used as an indicator of safe drinking water, a monthly test is recommended (a minimum is a quarterly, 4 per year, test). Frequent testing can assist in identifying problems and alerting the need for action. Additional testing is advised following an event which could jeopardize water safety, such as:

- Flooding or spills that could cause contamination
- Any evidence that water quality may have changed (taste, odor, color, turbidity, etc.)
- Frequent or unexplained illness of people or animals
- Poor livestock or animal performance (weight gain, litter size, mortality, health)

The choice of which test(s) to perform will be a judgment based on each situation. If potential contamination conditions are present near the well (i.e., landfill, chemical storage/handling, or fuel storage) it would be advisable to test more frequently and for a wider range of potential contaminants such as pesticides, synthetic organic chemicals, volatile organic chemicals, and radionuclides. See the K-State Research & Extension publication *Recommended Water Tests for Private Wells*, MF-871, for information on what to test for and how often.

Previously untested wells should be tested for basic water chemistry. This includes evaluation for the most common minerals and nuisance contaminants. Except in cases of gross contamination or a catastrophic event, basic chemistry usually changes slowly so re-testing every three to five years is adequate. A basic water chemistry test usually includes common cations (calcium, magnesium, sodium, iron, manganese) and anions (chloride, carbonate, bicarbonate, sulfate, nitrate).

Testing should be based upon past, present, and future site uses as well as groundwater quality data. It is advisable to contact a KDHE certified laboratory for specific sampling procedures, sample bottles, and the best time to collect and submit samples. K-State Research & Extension publications provide background information on recommended water tests and sample collection. See Appendix B for a brief description of the standards and significance for common inorganic chemicals. See Appendix C for Homeowner/User Water Quality Screening Results Interpretation and Recommended Corrective Actions For Wells.

Drinking Water Standards

Kansas' regulation of drinking water is authorized by state law, K.S.A. 65-171m. Primary drinking water regulations are outlined in K.A.R. 28-15a-1 through K.A.R. 28-15a-571. Kansas regulations adopt the US EPA Safe Drinking Water Standards by reference.

Drinking water standards are separated into two broad groups: primary standards or maximum contaminant levels (MCL), and secondary standards or secondary maximum contaminant levels (SMCL). Primary standards are established for substances which may produce adverse health effects (i.e., bacteria, heavy metals, other inorganic chemicals, and organic compounds). Public water supplies must not exceed the primary standards or regulations. A brief discussion of common inorganic drinking water contaminants is included in Appendix B.

In the absence of standards or guidelines for private water supplies, public water supply standards are recommended. K-State Research and Extension publications *Understanding Your Water Test Report*, MF-912 and *Organic Chemicals and Radionuclides in Drinking Water*, MF-1142 lists standards for inorganic and organic contaminants (see references).

Secondary standards are established for aesthetic purposes (taste, odor, appearance, etc.) and certain non-aesthetic effects. EPA recommends secondary standards to the states as reasonable goals. Secondary standards are not enforced by EPA or Kansas laws or regulations.

PROTECTION OF WELLS (WELLHEAD PROTECTION)

Without a well protection plan, there is an increase chance of groundwater contamination from activities near the well. Resultant effects are usually long term or permanent.

Wellhead protection is important because in addition to location and construction management of activities near the well may affect the groundwater or aquifer supplying the well. Groundwater does not recognize property boundaries and may extend hundreds or even thousands of feet from the well site, especially up-gradient in groundwater flow. Protection offered by the soil is missing whenever it is missing or penetrated by abandoned wells, rock quarries, gravel operations, test holes, or other holes. The well's water quality depends on protection and nearby surface activities.

Potential contamination can be decreased or increased by location of the well. Generally it is best to locate wells as far as practical from sources of contamination, both biological and chemical. Wells located up gradient in groundwater flow direction (usually up-slope on the surface), have a reduced risk of contamination from nearby sources. Surface water should be redirected by installing a diversion, a sloping channel with an integral ridge below, so water does not flow near the well.

The effects of surface activities many times are not immediately obvious, but may have long term consequences. Surface activities that can affect groundwater include application of fertilizer and pesticide, confined animal feeding operations, fuel storage, and failure to provide adequate backflow protection on the plumbing system. It is a fact that excessive fertilization of lawns and crops as well as spills near a well can contribute to an increase in nitrate concentration in the groundwater. Spills that occur while loading and mixing pesticides as well as the practice of flushing containers or equipment onto the ground near a well can contaminate it.

The best protection for private wells from contamination occurs when a wellhead protection plan exists in writing, is followed, and is reviewed regularly. The *River Friendly Farm Plan – Environmental Assessment Tool* and *Kansas Home•A•Syst, An Environmental Risk Management Guide for the Home* materials are available and may help in preparing the plan. First, potential sources of contamination are identified and their relative risk quantified. Then the highest risks, together with actions to reduce these risks are summarized. Finally the owner acts to correct the highest risks first, then the next highest risks until all risks are reduced to low risks.

A good wellhead protection plan involves careful planning and should include a primary and secondary protection area or zone as shown in Figure I-1. In the primary protection zone all high risk activities and conditions are prevented and moderate risk activities include measures or management to reduce them to low risks. The radius for the primary protection zone should be a minimum of 100 feet with up to 300 feet or more recommended.

In the secondary protection area or zone, high risk activities or situations employ additions or management to shift them to low or moderate risks. Moderate risk activities include measures of management to shift them to low risks. The radius for the secondary protection area should be a minimum of 200 feet with 400 feet or more preferred. Guidelines for high, moderate, and low risks are shown in Table I-4.

Table I-4. Relative Contamination Risks for Home and Farmstead Activities

Group A: High Risk

- Polluting liquids without secondary containment such as fuel, solvents, chemicals (fertilizer, pesticide, etc.)
- Liquid waste (sewage, manure, etc)
- Water-soluble materials like fertilizer, pesticides
- Livestock lots, abandoned livestock lots and other wastes
- Buildings and areas where the above materials are used, transferred, mixed, stored or cleaned up (such as: shop or sprayer fill/clean up area)
- No backflow prevention for the water system

Moderate Risk

- Intensive cropland especially irrigated land where chemicals (fertilizer or pesticide) are applied, gardens, home and yard
- Powered equipment storage (tractors, truck, auto, etc),
- Garage, grain storage, silo
- Livestock buildings with minimum liquids

Low Risk

- Pasture rangeland, woodland, low intensity (low or no chemical) cropland,
- Nonpowered machine storage,
- Windbreak,
- Low use buildings,
- Organic garden, organic cropland,
- Liquid storage with full secondary containment and careful management
- Water soluble materials with full spill protection, cleanup and careful management
- Air gap maintained for all filling operations and backflow prevention is used throughout the water system

PRESSURE TANKS

Most electrical water pump systems include a pressure tank to stabilize water pressure and to relieve the pump from running each time a small quantity of water is used. Pressure is obtained by compressing the air when the water is pumped into the pressure tank. The pressure tank may have a divider to prevent the loss of captive air in the tank. Various air retaining methods have been developed due to the tendency of water to absorb air and the tank to become "waterlogged". Examples of different pressure tank sections are illustrated in Figure I-14.

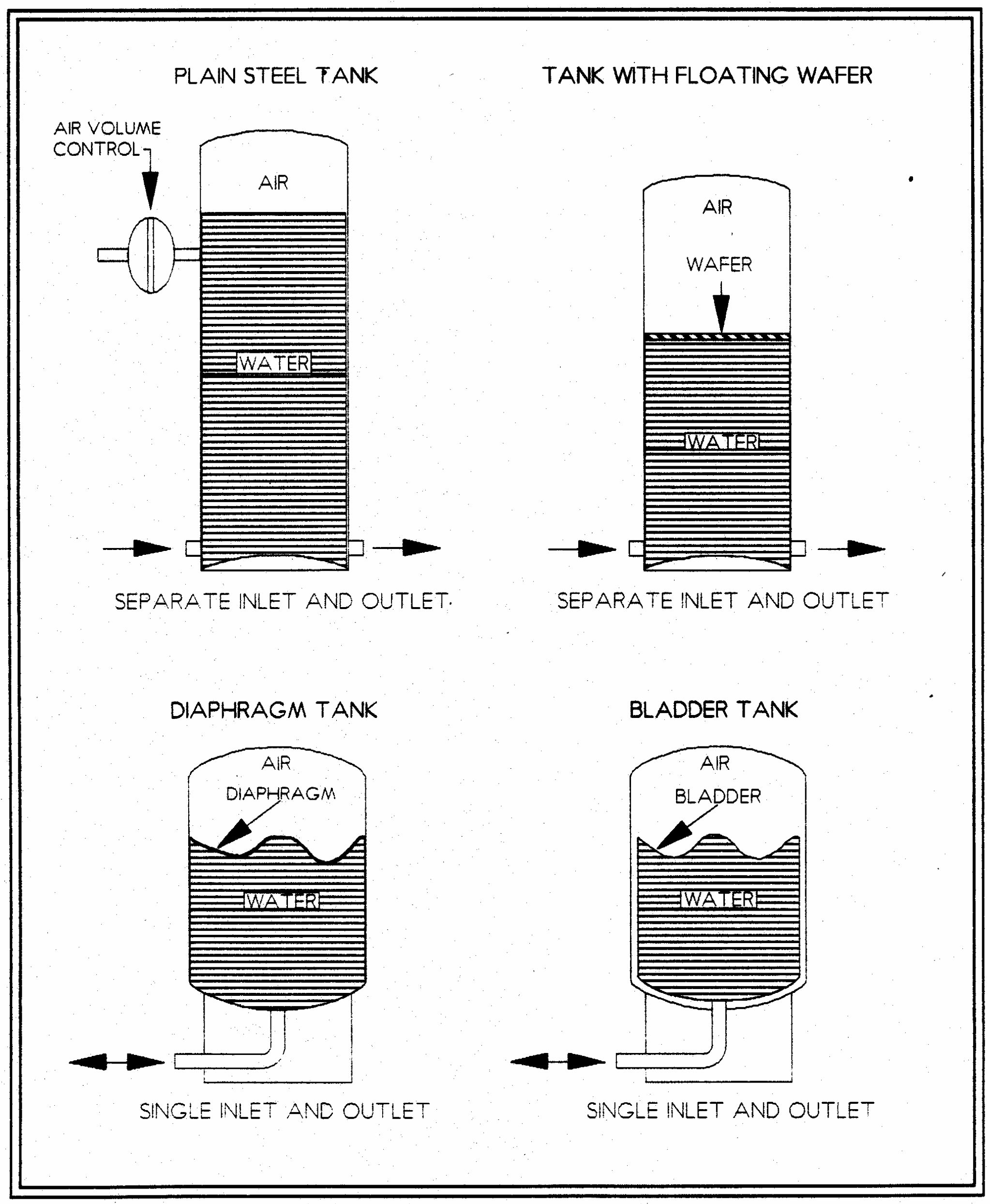


Figure I-14. Pressure Tank Styles

WATER STORAGE TANK

In some areas of the state there are no water-bearing formations (aquifers) that will yield sufficient quantities of potable water. As indicated earlier, the best water source for domestic use in rural areas without usable aquifers is the rural water district. Where a water district supply is not available, the use of a properly constructed and equipped water storage tank of food grade material is a possible solution.

Water placed in a storage tank should be obtained from a public water supply and should be transported to the reservoir in a clean, closed, food grade tank used **exclusively** for hauling potable water. All reasonable precautions should be taken to prevent contamination of the water during the transporting, loading and unloading processes. It is a good practice to periodically rinse the tank with a solution of chlorinated water and discharge the rinsate solution onto the ground away from any surface water drainage areas and vegetation.

CROSS-CONNECTION CONTROL

This section is intended as an introduction to the subject of cross-connection and backflow control. It is not within the scope of the section to address specifics. A bibliography of reference materials is included at the end of this chapter.

In plumbing, the term **cross-connection** refers to a **permanent** or **temporary** connection between a potable (drinking) water system and any other source or system containing nonpotable water or any other substance. Cross-connections are a recognized public health problem with many documented cases of accidents, illnesses, and even deaths. Any water supply, from a large municipal system to a private single family or farmstead system, can be subject to cross-connection problems. Permanent or temporary by-pass arrangements or jumper connections are common cross-connection problems. For example, the common garden hose with the discharge end in a bucket or tank is a cross-connection because it is subject to possible back siphoning.

There are two types of cross-connections: direct and indirect. The difference between the types of cross-connections is very simple. A direct cross-connection is subject to backpressure; an indirect cross-connection is not subject to backpressure. When a cross-connection is present, contamination of the potable system may occur as the result of backflow (reverse flow of water), other liquids, or gasses into the water system. Backflow may be caused by backsiphonage, backpressure, or a combination of the two. This is an undesirable situation because contaminants are often introduced into the potable water system with the backflow.

Backsiphonage is a backflow condition caused by a vacuum or partial vacuum in the water-supply system. This can be caused by gravity, undersized piping or induced vacuum. Gravity backsiphonage occurs when the water flow is interrupted and an elevated valve is open allowing a reversed flow. This could occur when the water supply to a two story house is temporarily interrupted by shut off or loss of power. During this period if someone should open a valve on the first floor, water would flow from the second floor to the first floor faucet. Backsiphonage due to undersized piping may occur when water moving at a high velocity aspirates or draws water from branch piping into the rapidly moving stream. This may occur when a valve is opened but water does not come out with pressure.

Backpressure backflow is caused when a higher pressure is exerted from some point downstream than is present in the piping system. Examples would include a booster pump used for livestock watering or a second livestock water system connected to the household system.

Both backsiphonage and backpressure can be caused by high volume pumping of water from the system. Such an incident might occur when a fire engine is pumping water from a fire hydrant. There are five basic backflow prevention devices that can be used for cross-connection control discussed in the following paragraphs:

Air Gap is a physical separation of the water supply from the nonpotable source using an air gap with a vertical separation distance of at least two times the supply pipe diameter. An air gap provides excellent protection against both backsiphonage and backpressure. **The air gap is usually the simplest, least expensive, and most reliable method of protection from contamination by cross-connection**. An air gap is the only acceptable means of protecting against lethal hazards.

Atmospheric Vacuum Breaker (AVB) is a simple device with an internal mechanism which, in the event of interrupted flow, provides an atmospheric vent to prevent backsiphonage. The AVB is to be installed in a vertical position with no restrictions down stream and the outlet at least six inches below the AVB. This backflow device is commonly used for outdoor hose connections and toilet and urinal flush valves. It is considered suitable for low hazard backsiphonage protection.

Pressure Vacuum Breaker (PVB) is a spring loaded check valve designed to close when flow stops. It also has an air inlet valve which is designed to open when the internal pressure is 1 pound per square inch (psi) above atmospheric pressure. When flow stops the vent opens to prevent backsiphonage. Being spring loaded it does not rely upon gravity to operate as does the atmospheric vacuum breaker. The unit has shutoff valves and test cocks (which should be tested annually to be considered safe) and may be operated under continuous pressure with valves downstream of the device. This device does not provide acceptable protection against backpressure.

Double Check Valve Assembly (DC) is a device consisting of two internally loaded, independently acting check valves with shutoff valves upstream and downstream. The unit also has testcocks and must be tested annually to be considered reliable. This is commonly used at the household water service connection just downstream of the water meter. The DC can be used in low hazard situations to protect against either backsiphonage and backpressure.

The Double Check Director Assembly (DCDA) is a variation of the double check valve. This assembly is used when the protection of the double check valve assembly is required yet where the added requirement of detecting any leakage or unauthorized use of water exists. These assemblies are commonly used for fire sprinkler lines.

Reduced Pressure Principal Assembly (RP) is a device consisting of two internally loaded and independently operating check valves and a mechanically independent, hydraulically dependent relief valve located between the check valves. This relief valve is designed to maintain a zone of reduced pressure between the two check valves at all times. The unit has shutoff valves and test cocks and must be tested by a licensed and trained plumber annually to be considered reliable. In case of check valve leakage, it discharges to the atmosphere thus preventing contamination of the water supply. This device is used for backsiphonage and backpressure protection of potable water supplies from high hazard situations such as chemical feeds.

The Reduced Pressure Principal Director Assembly (RPDA) is a variation of the reduced pressure principal assembly. It is similar to the DCDA in that the bypass meter must register accurately at low flows. This assembly is normally used on fire sprinkler lines which may contain freeze protection or other additives.

The choice of device is dependent upon the degree of hazard posed and local code requirements. To be effective, cross-connection control devices must be properly installed and regularly tested by a trained technician as required. Education concerning potential cross-connection problems is essential to effectively address cross-connection potentials located on private premises.

COMPLAINT INVESTIGATION AND EVALUATION OF EXISTING WELLS

It is common for the sanitarian or county health or Extension office to receive complaints of bad taste, bad odor or other problems. A good response to this requires a thoughtful and thorough site investigation and evaluation of the well and water system. The cause of such problems may be from more than one source. A data collection form is included in Appendix D that can be used to help identify possible sources that may contribute to the problem.

When a request is received to evaluate an existing well for an owner or as required for a property transfer, a careful evaluation of the properties of the well are essential. Many lending institutions require such evaluation to help protect from the possible expense of a water supply correction in the event of a loan default. The investigation depends on collecting accurate information about the well and water system. The owner is in the best position to know answers for many of the well questions. Obtain information about the well or water system from the owner. For guidance about conducting a well evaluation see Protocol: Well Evaluation for a New Site or Existing Private Well and the accompanying data sheet at the end of this chapter.

If the well was installed since 1975 a well log should be available that would document the construction and materials. Possible sources include the owner, the well driller, Kansas Geological Survey web site, and KDHE records. If no well log can be found or the well was installed prior to the 1975 Well Construction Act and construction is unknown, assume that grout does not meet current well construction standards and likely is totally missing. A well that is not adequately grouted is very vulnerable to contamination from the surface and is not a safe well.

PLUGGING ABANDONED WELLS

The plugging of abandoned wells is required by Kansas law and is the responsibility and sole duty of the landowner (K.A.R. 28-30-7). Kansas landowners may qualify for cost share assistance through the county conservation district to help offset the cost of well plugging. They can either hire a Kansas Licensed Water Well Contractor to plug the abandoned or recently used well or do it themselves. Local Codes may require more stringent standards and should always be consulted. A landowner who plugs an abandoned well must follow the Kansas plugging regulations and must also file a record of the well plugging with KDHE (K.S.A. 82a-1212) using their Form WWC-5 (or WWC-5P). For more information about plugging a well see KDHE, Bureau of Water web site <www.kdhe.state.ks.us/waterwell> or K-State Research and Extension publication *Plugging Abandoned Wells*, MF-935. Wells that meet certain minimum standards may be put on an inactive status by completing KDHE *Inactive Water Well Request*, form WWC-6 KSA.

REFFERENCES AND READING MATERIALS

Publications Regarding Private Wells and Related Topics

Available from K-State Research and Extension, Distribution Center, 34 Umberger Hall, Manhattan, Kansas, 66506-3402.

How Kansans Obtain Safe Drinking Water, MF-2333

Kansas Home•A•Syst, An Environmental Risk Management Guide for the Home, June 1999

Kansas Home•A•Syst: for Home Based Occupations and Hobbies, July 2001

Measuring Depth to Water in Wells, MF-2669

Obtaining Safe Water from Private Wells, MF-2345

Organic Chemicals and Radionuclides in Drinking Water, MF-1142

Plugging Abandoned Wells, MF-935

Plugging Cisterns, Cesspools, Septic Tanks, and Other Holes, MF-2246

Prevent Spills and Release of Contaminants, MF-2549

Private Water Well – Owner/Operator Manual (folder), MF-2409

Private Wells – Safe Location and Construction, MF-970

Private Well Maintenance and Protection, MF-2396

Process Water – Minimizing Microbial Food Safety Hazards for Fruits and Vege's, MF-2480

Recommended Water Tests for Private Wells, MF-871

River Friendly Farm Plan – An Environmental Assessment Tool, S-138 www.oznet.ksu.edu/rff/

Safe Water from Wells (video), SV-386

Shock Chlorination for Private Water Systems, MF-911

Shock Chlorination Treatment for Irrigation Wells, MF-2589

Sodium in Drinking Water, MF-1094

Sodium in Public Water Supplies, MF-1114

Taking a Water Sample, MF-963

Testing to Help Ensure Safe Drinking Water, MF-951

Understanding Your Water Test Report, MF-912

Water Supply for Food and Beverage Processing Operations, MF-1122

Why Use Pollution Prevention, (video) SV-176

Available from Kansas Department of Health and Environment, 1000 SW Jackson St, Suite 420, Topeka, Kansas, 66612.

Article 12. Groundwater Exploration and Protection Act, effective September, 1993. www.kdhe.state.ks.us/waterwell/download/article12.pdf.

Article 30. Water Well Contractor's License Water Well Construction and Abandonment, effective May, 1987. www.kdhe.state.ks.us/waterwell/download/article30.pdf.

Policies, General Consideration, and Design Requirements for Public Water Supply Systems in Kansas, 1995. www.kdhe.state.ks.us/pws/peu.html#permit.

How to Review a Water Well Record (WWC- 5 Form and WWC-5p Form) for Compliance to The Water Well Regulations, 2004. www.kdhe.state.ks.us/waterwell/download/WWP-7.pdf

Available from MidWest Plan Service, 122 Davidson Hall, Iowa State University, Ames, IA 50011, phone 800-562-3618, web address www.mwpshq.org/catalog.html.

*Home*A*Syst – An Environmental Risk-Assessment Guide for the Home*, NRAES-87, 122 page handbook, 1997. This handbook helps homeowners and renters in rural and suburban areas assess the home and property for pollution and health risk.

Home Water Treatment, NRAES-48, 128 page handbook, 1995. This two-color manual explains water quality and testing, the basics of water treatment, methods of physical and chemical treatment, and equipment used.

Private Water Systems Handbook, 4th Edition, MWPS-14, 72 page handbook, 1979. This well-illustrated, two-color handbook addresses water quantity and sources, then describes all aspects of constructing, repairing, and maintaining a private water system.

Private Drinking Water Supplies, NRAES-47, 64 page handbook, 1991. Water quality professionals and anyone else wishing to evaluate a private or public water supply will find useful information here.

Reviewers of the Private Water Well Section of the EHH, First Edition, 1998

Darrell Clarke, Clarke Well and Equipment, Inc., Great Bend, KS

Richard Harper, Kansas Dept. of Health and Environment, Bureau of Water, Topeka, KS

Bruce Reichmuth, Henkle Drilling Company, Inc., Garden City, KS

Scott Shields, KDHE, Northeast District Office, 800 West 24th, Lawrence, KS

Margaret Townsend, Kansas Geological Survey, University of Kansas, Lawrence, KS

Dr. Donald Whittemore, Kansas Geological Survey, University of Kansas, Lawrence, KS

Dwight Brinkley, Consultant, Lawrence, KS, did final editing and prepared figures for the first edition of this chapter for the Environmental Health Handbook

PROTOCOL

EVALUATION OF A NEW WELL SITE OR AN EXISTING PRIVATE WELL

GOAL: Evaluate whether proposed well location or existing well location and construction meets existing codes, regulations, and guidelines for private wells.

POLICY: The site evaluation will be completed following application to the administrative agency by the landowner, purchaser, contractor, lender, or other involved party. A report summarizing the evaluation should be provided to all individuals who have legal interest in the property. When the site has restrictions, the report shall document reasons for those restrictions and where appropriate offer reasonable alternatives. A file of all original documents including: letters, data, supporting information, etc. shall be maintained by the administrative agency.

PROCEDURE:

1. The applicant shall provide a map and complete the application (see sample included) to request the site or well evaluation. The applicant's signature shall provide assurance of completeness, accuracy of information, and give the agency permission to enter the property as needed to conduct the evaluation and take samples. The well log for all existing wells should be provided when such exists.

2. The applicant should be informed that he or she is responsible for collecting information about groundwater availability and quality. Possible sources include Kansas Geological Survey, web site <www.kgs.ku.edu>; DASC, web site <gisdasc.kgs.ku.edu>; and Kansas Department of Health and Environment contaminated site information, web site <www.kdhe.state.ks.us/remedial/isl_disclaimer.htm>. The applicant should be provided with a copy of current local code requirements for wells.

3. The inspector collects available information about the site from the soil survey, current aerial photo from county appraiser, any available agency records, and other sources as appropriate. Include information such as photos that would document historical land use and possible contaminant sources.

4. A site visit shall be made by the inspector to examine the proposed or existing well location. The landowner (or his or her representative) should be present, if possible, as well as other interested parties.

5. The proposed site shall be evaluated for conditions which could limit the location or provide evidence of possible contamination for a well. Such conditions include, but are not restricted to current and historical land uses, especially separation distances in Table I-2.

6. The proposed well location(s) selected by the applicant shall be marked with flags.

Well or Well Site Evaluation Protocol Continued – Page 2

THE SITE VISIT

Preparation for the Visit

1. Obtain readily available information including site plan, map, and soil survey map.
2. Make an appointment for a site visit with the appropriate people.

For New and Existing Well Sites

1. Locate existing well or prospective well locations.
2. Visually identify contamination sources and topography within a 400 foot radius from the well or location. The ground surface should slope away for the well in all directions, or if located on a slope, a stormwater diversion should be provided on the uphill slope.
3. Measure and record setback distances from property boundaries, easements, and current and known historical contamination sources, see Table I-2.
4. Evaluate and record approximate well elevation with respect to potential contamination sources. An instrument such as a hand level, clinometer, contractors level, engineers level, or laser level with appropriate eye height rod or level rod are essential for this task.

For an Existing Well

1. Casing must extend at least 12 inches above surrounding natural ground surface and surface must slope away from the well in all directions.
2. Casing must be of approved material (Schedule 40 steel or PVC) with no penetrations of the casing except for a pitless adapter which shall be double gasket sealed to the casing.
3. Sanitary seal must be of KDHE approved type with no modifications; securely installed; all fittings secure and water tight; and downward opening vent screen in place, clear, and secure. If used, ropes must be contained inside the casing and cap and electrical wiring contained in conduit with water-tight fittings. Confirm that the sanitary seal gasket is compressed tightly around casing and all penetrations.
4. If the well log does not exist (i.e. well drilled prior to 1975 or the driller did not complete paperwork) assume that grout does not exist and indicate the lack of grout on the report. A probe inserted adjacent to the outside of the casing may help evaluate the existence and type of grout.
5. Obtain the type and rating of the pump and note location, type, and capacity of pressure tank.
6. Record location and description of all water treatment devices (including filters) attached to the water system.
7. Ask questions and look for evidence of cross-connections with other water sources and possible backflow hazards.

Note: Do not collect a water sample for bacteria analysis from a well that does not meet well construction standards.

Well or Well Site Evaluation Protocol Continued – Page 3

Sampling and Testing

1. Collect a water sample for coliform bacteria **only from properly constructed wells**.
2. Check the water source to assure that there is no chlorine residual. Do not collect a bacteria sample if any chlorine residual exists.
3. Collect sample from an indoor water faucet that is in regular use where water has not been through a treatment device. KDHE advises not to use a swinging faucet as on a kitchen sink.
4. Follow laboratory, KDHE, or K-State Research and Extension guidelines for collecting the water sample for bacterial analysis. Collect a separate water sample for screening nitrate level.
5. Recommended sampling: chlorine residual, total and fecal coliform bacteria, nitrate as nitrogen [NO_3 – N]. Testing pH and total dissolved solids [TDS] are also encouraged to establish baseline conditions and changes in water properties (indicate possible pollution sources) that may have health effects.
6. Because lead [Pb] is a health concern testing is recommended whenever lead pipe has been used. It may be a concern and testing is suggested when pH and TDS levels are low and there is a source of lead in the system including in brass pump parts and plumbing fixtures, or in solder containing lead.
7. If the nitrate concentration is high (above 10 mg/L) and pesticide usage, storage, handling, mixing, spills, or clean up have occurred within 400 feet of the water source, then testing for the specific pesticide(s) is recommended. If NO_3 is high and chemicals other than pesticides have been used, stored, handled, mixed, spilled, or cleaned up within 400 feet, testing for those chemicals is suggested.

Reporting and Cautionary Statements.

1. Provide verbal and written educational material to buyer and seller related to protection of their water supply in the form of a letter with brochures, pamphlets, publications, inspection form, and/or handout materials. Suggest completion of *River Friendly Farm Plan - Environmental Assessment Tool* or *Home ✻A ✻Syst* as a practical way to do a private well assessment, wellhead protection plan, and action plan to improve protection. See references.
2. Written documentation describing the evaluation should be provided to all individuals who have an interest in the outcome of the assessment (i.e., buyers, sellers, lenders, realtors, zoning boards, and contractors).
3. In situations where the site evaluation found deficiencies, the report shall document the findings and provide reasons and if possible offer a reasonable alternative.
4. A file of all data collected, reports, documents, and letters for that property shall be maintained by local authority.

WELL SITING AND WELL EVALUATION APPLICATION AND DATA
Sample Form for Use with Well Evaluation Protocol

Date: ________________________ Applicant: ______________________________________

Location: Co. _________________,_____¼, _____¼, _____¼, Sec.____, T____S, R____E/W

Subdivision: __________________________ Lot #: ______________ Parcel #: ___________

Owner(s): ___________________________

Address: ____________________________

____

____

Phone: H:____________ O: ____________

Renter(s): _____________________________

Address: ______________________________

____

____

Phone: H: ______________ O:_____________

Owners Agent:______________________________ Phone: ___________________________

Driller: ____________________________ Phone: ________________ License #: _________

Well Depth: _____ Water Depth: _____ Year Constructed: _____ Year Reconstructed: _____

Well Yield: ________________________ Well Logs: Not Available / Available / Attached

Indicate All Well Uses: Household / Livestock / Lawn & Garden / Other: _________________

List All Water Treatment Devices: ____

Reason for Inspection: ______________________________ Contact: ____________________

Well History (Investigations / Complaints / Past Water Tests / Maintenance / Repairs etc): ________________

____

____

____

This information is complete and accurate to the best of our knowledge. Permission is granted for entry, inspection, and sampling as needed.

Above part to be completed by applicant. Signature: ________________________________ Date: __________

SITE INSPECTION Inspector: ____________________ Date: ________

Well Type: New / Reconstructed / Existing / Abandoned / Other: _________________________

Well Construction: Date: _________ Method: Drilled / Driven / Hand Dug / Other: __________

Pump Type: Submersible / Jet / Hand Pump Other: __________ Size (gpm/hp) ______________

Pressure Tank: Size _________ (gal.) Type: ______________ Material: __________________

Water Treatment Devices (mark all used): sediment filter, carbon filter, water softener, reverse osmosis, distiller, other: ____

Potential Sources of Contamination, (Existing and Previous) within 1/8 mile (660 ft.)

Contamination Type Direction and Distance from Well

____ Wastewater systems ____

____ Livestock confinements ____

____ Petrochemical and fuel storage ____

____ Pest./Fert. storage/handling/cleanup ____

____ Other hazardous activities ____

____ Proximity to bldg. foundation ____

____ Other used/unused wells ____

____ Other: ____

Required Setbacks (separation distances) (Have, Have not) been met (list): ____________________
____

TEST RESULTS: Total Coliform: ______ Fecal Coliform/*E. coli*: _______ Nitrate: ________
Chlorine: _________ Other (attach report): _____________________________________

CONDITION of WELL CONSTRUCTION:

____ Ground surface slopes away from well in all directions for at least 20 feet and surface water does not pond within 50 feet.

____ Casing is at least 12 inches above surface grade or high water level.

____ Sanitary seal approved, properly installed, tight, & unmodified (brand/model): ____________

____ Top of well appears to be tightly sealed but is not an approved type.

____ Identified potential cross-connection, backsiphonage, or backpressure (where and what):
____

____ Casing from 12 in. above ground to top of well screen is approved and seems watertight.

____ Casing properly grouted (how determined) ____

Casing diameter: ______ ID / OD Pitless Adaptor/Unit approved type & secure: ____________

Casing Material: PVC ____, ABS ____, Steel ____, Iron ____, Other ___________________

Other comments: ____
____
____
____

Recommendations to upgrade well: ____
____
____
____

Appendix A. WELL DISINFECTION

Before a well is disinfected, it should be inspected to assure that it is not being contaminated due to poor location, poor construction, damage or inadequate maintenance. If a well is poorly constructed, allowing the entry of surface water, dirt, insects, or other contaminants, then chlorination of the well and the water system will provide only a temporary solution to the problem. If the well appears to be sealed to keep contaminants out, or if repairs or changes have been made to the pump, well or, other parts of the water system, then proceed with shock chlorination of the well and water system as follows:

1. Remove the sanitary well seal and place it into a clean container. Pour an appropriate amount of chlorine solution into the well casing. The amount of chlorine solution to use is not less than one-half (½) gallon of chlorine bleach containing 5¼ percent sodium hypochlorite to 100 gallons of water.

2. Attach a garden hose to a tap or water hydrant that is supplied water from the well and place the free end of the hose into the top of the well casing. Circulate the chlorinated water from the well through the hose and back into the well by opening the valve, tap or water hydrant to which the hose is attached. Manually rotate the discharge end of the hose in a circular motion around the inside of the well casing. This allows the chlorine solution to wash down the interior wall of the well casing and the exterior wall of the pump column pipe. This procedure is repeated and continued for at least 15 minutes **after a strong** chlorine odor is detected from the discharge end of the hose. A good practice is to allow the recirculating hose to continue to flow while step 3 is being done. Be sure to wash down the sanitary well seal with the chlorine solution. The top of the well casing then should be resealed by installing the clean sanitary well seal (never leave the top of the well open).

3. Open a different outside tap, closest to the well, and let the water run to waste until the unmistakable strong odor of chlorine is detected. Close that tap and proceed to the next closest tap to the well and repeat the discharge of the chlorinated water. Continue this procedure, tap by tap, throughout the entire distribution system (both cold and hot water lines) including hydrants, faucets, toilets, and showers until the chlorinated water is distributed throughout the entire water system. If at any time no chlorine odor is noted in the water at any tap, repeat the procedures in Steps 1 and 2 above. After distributing the chlorinated water throughout the distribution system allow the chlorinated water to remain in the distribution lines for a minimum of 12 hours. Do not use any of the water during this time period.

4. After the chlorinated water has been in the lines for at least 12 hours, open an outside tap and flush the chlorinated water to waste until no chlorine odor is detected. This large volume of highly concentrated chlorine should not be discharged to the septic system nor should it be discharged to the surface in contact with vegetation which the owner wishes to maintain. Flushing onto a gravel drive or road is acceptable. Continue to flush the system tap by tap, leaving inside faucets until last. Do not allow anymore high chlorine water than absolutely necessary to be wasted to the wastewater system.

5. Wait at least seven (7) days or more after chlorination before taking another water sample to be tested. Before taking the water sample it should be tested to make sure the sample does not contain any chlorine. Water samples may be collected by the local health department or the homeowner. Samples which will be forwarded to a certified laboratory must be sent to the laboratory the same day they are collected, and submitted only in sterile containers supplied by a state certified laboratory. The test for total and fecal coliform should begin at the certified laboratory within 24 hours of sample collection.

In cases where contaminated water has entered the well, such as from a flood or damaged casing, a more elaborate shock chlorination procedure may be required. The recommended procedure is to use a 300 to 500 gallon clean tank that is constructed of food grade materials that has not had contaminants in it. Mix up a strong chlorine solution in the tank and allow it to flow into the well. In the case of a deep well with lots of water this may have to be repeated two or more times. The objective is to get the chlorinated water into the gravel pack and aquifer formation surrounding the well. The chlorinated water should remain in the well for at least 24 hours.

Three times during the process, pump out a tank full and then let it run back into the well. This mixes the chlorine and forces the solution through the formation. If a strong chlorine odor is not detected, add more chlorine to the tank before letting it flow back into the well. If the water becomes murky with residue, pump the contents to waste until clear water is achieved and begin the process again.

For more detailed instructions about shock chlorination including tables to help determine water volume and chlorine doses, see K-State Research and Extension publication *Shock Chlorination for Private Water Systems*, MF-911.

Appendix B. COMMON INORGANIC DRINKING WATER QUALITY PARAMETERS

ALKALINITY (CaCO3). The recommended value for alkalinity is between 60 and 100 mg/L. The alkalinity of water is a measure of its capacity to neutralize acids. Bicarbonate and carbonate are the major contributors to alkalinity, but borate, hydroxide, phosphate and silicate also contribute. The relationship of pH, calcium and alkalinity determines whether a water is corrosive or whether it will deposit calcium carbonate. Water with an alkalinity value below 50 mg/L may be corrosive, which could cause deterioration of plumbing and an increased chance for lead in water, if present in pipes, solder or plumbing fixtures. Alkalinity greater than 500 mg/L will be noticeable hard, but does not have any adverse health effects. Alkalinity is an indicator of the stability of water (see Langlier Stability Index worksheet).

CHLORIDE (Cl). The suggested limit for chloride is 250 mg/L. Some people can detect a salty taste when chloride exceeds 250 mg/L. Chloride has no known physiological effect.

FLUORIDE (Fl). The maximum contaminate level (MCL) for fluoride is 4.0 mg/L with a suggested limit of 2.0 mg/L. A fluoride concentration of approximately 1.0 mg/L helps prevent dental caries (cavities in teeth) but below 0.7 mg/L, fluoride will not be of any benefit. At concentrations above 1.8 to 2.0 mg/L, fluoride may cause mottling of the teeth. This is most commonly a problem for children up to 10 years old while permanent teeth are forming.

HARDNESS (CaCO3 equivalent). Total hardness over 400 mg/L (23.4 grains per gallon) is considered excessive in Kansas. Calcium and magnesium are the principal minerals contributing to total hardness. Hard water has a tendency to develop scale deposits, especially when heated above 140° F. If the thermostat on the hot water heater is set too high, excessive scale may form. This scale can be carried into the water pipes and will plug up screens on faucets and appliances. Soft water may be corrosive, and can slowly dissolve metal pipes or metal plumbing fixtures. Acceptable levels for hardness are based on the user's preference, cost to treat, cost for increased cleaning and laundry, shortened life of appliances, and increased water heating costs for hard water.

IRON (Fe). The suggested limit for iron is 0.3 mg/L. Iron contaminated water is objectionable because of taste or odor and it often causes reddish-brown stains to develop on bathtubs, sinks and toilet bowls. It can also stain laundry a pink or reddish color. Iron has no significant direct adverse health effects but people may not drink enough water. Animals may be sensitive to changes in iron concentrations in their drinking water. Dairy cows may not drink enough water to maintain optimum milk production if the water is high in iron. Dissolved iron in water used for washing and sanitizing milk-handling equipment may impart an oxidized or cardboard-like flavor to the milk.

Frequently, water with dissolved iron also shows evidence of iron bacteria. These organisms use the iron as a source of energy and accumulate in masses that may plug well screens, pumps and pipelines. In time, a rust-colored, jelly-like mass will break loose and enter the plumbing system. Iron bacteria coat nearly everything, including toilet tank, pipes and storage tank. Decaying dead bacteria impart a bad taste and odor to the water and leave stains that are very difficult to remove.

MANGANESE (Mn). The suggested limit for manganese is 0.05 mg/L. Manganese contaminated water is objectionable because it may impair the taste of tea, coffee and other beverages and produce black or gray color in laundered goods, and cause dark stains on plumbing fixtures and showers. Manganese may form a coating on distribution pipes which may become detached, causing dark stains on laundered clothing or black particles in the water. Manganese has no physiological effects.

NITRATE (NO3). The MCL for nitrate, is 10 mg/L as nitrate nitrogen (NO3-N). Nitrate values are usually expressed as nitrogen (N), but may be expressed as "NO3". When expressed as NO3 the drinking water standard is 45 mg/L.

An annual check of nitrate is recommend with additional checks before pregnancy, during pregnancy and when infants (less than one year) are present or will be present. Excessive nitrate may cause infant cyanosis, also known as methemoglobinemia or "blue baby syndrome", in children less than one year of age. Pregnant and lactating women should also avoid water above this standard. A known safe water source should be used to mix formula or to feed the infant until one year of age. Children over one year of age and adults may be able to safely drink water with nitrate concentrations above the standard and even much higher for short periods. However, concentrations more than twice the standard (20 mg/L) are considered an unreasonable risk to health. Boiling water concentrates rather than remove nitrate so this make the problem worse. The best control is to eliminate excess nitrogen sources within at least 200 feet of the well.

Nitrate greater than 20 to 30 mg/L (as N) can be of concern in water used for livestock. Poor conception rate, increased abortion rate and a loss of feed conversion may occur in livestock. Nitrate from water and feed sources is additive. Consult your veterinarian or Extension Office if you suspect a problem with nitrate for livestock.

POTASSIUM (K). The concentration of potassium normally found in drinking water has no physiological or aesthetic effects on drinking water users.

SODIUM (Na). Persons on a restricted sodium diet need to be aware of the sodium level in their drinking water, especially if the sodium value is greater than 100 mg/L. If you are on a low sodium diet, consult your physician or dietitian about sodium in water. People not on a restricted sodium diet do not need to be as concerned about the sodium level in their drinking water. Water softeners which are recharged with salt further increase the sodium.

High sodium levels may adversely affect the use of water for irrigation purposes. A relationship between the ratio of sodium and total hardness in the water, the type of soil being irrigated, and the type of crops being irrigated, determine if water can be used for irrigation. For further information on whether water can be used for irrigation contact your County Extension or Natural Resource Conservation Service office.

SULFATE (SO4). The suggested limit for sulfate is 250 mg/L. High sulfate concentrations in drinking water have three effects:

1. formation of hard scales in boilers and heat exchangers,
2. bitter taste, and
3. laxative effects for those not used to it.

Diarrhea can be induced, especially for those who are not used to the water, at sulfate levels greater than 500 mg/L but more typically near 750 mg/L. After a few days or weeks, people and animals usually adjust to the sulfate and then are not bothered by the laxative effect. People and animals that are used to high sulfate water may experience constipation from low sulfate water.

TOTAL DISSOLVED SOLIDS (TDS). The suggested limit for TDS is 500 mg/L but many water supplies in Kansas exceed 1000 mg/L. Total dissolved solids is a measure of the dissolved minerals in the water. Its value is useful in determining the usability of the water. The approximate value of TDS can easily be calculated by adding the values of calcium, magnesium, alkalinity, chloride, sulfate, nitrate and fluoride. Water with a TDS greater than 1000 mg/L may have adverse effects, such as a laxative effect on people not accustomed to the water, and is objectionable because of the mineral taste and possible physiological effects.

Water with a TDS less than 500 mg/L will have no adverse effect for watering animals. A TDS of 1000 to 3000 mg/L is acceptable for watering livestock, but may cause diarrhea in livestock not accustomed to the water or watery droppings in poultry. Water with a TDS of less than 500 mg/L should have no adverse effects for irrigation. A TDS of 500 to 1000 mg/L can have adverse effects on sensitive crops such as radishes, beans, and fruits. Water with TDS values of 1000 to 2000 mg/L can be used for irrigation but may require specific management practices especially for some crops. TDS over 2000 mg/L may not be suitable or will require detailed management.

SIGNIFICANCE OF INORGANIC WATER ANALYSIS - HEAVY METALS

ARSENIC (As). Maximum contaminant level (MCL) is 0.05 mg/L. Chronic health effects may include weight loss, depression and lack of energy. The high toxicity of arsenic and its widespread occurrence in the environment necessitate the limit on arsenic concentrations in drinking water. At one time arsenic compounds were used extensively as pesticides but their use for these purposes has been dramatically reduced. Arsenic is one of the few known human carcinogens.

BARIUM (Ba). MCL is 2.0 mg /L. Barium is fatal to humans in doses over 550 mg/L. Barium can accumulate in the liver, lungs and spleen. It can cause nervous system disorders, heart disease and circulation impairment. No study appears to have been made of the amount of barium that can be tolerated in drinking water, but because of its toxic effects on the heart, blood vessels and nerves, a level with a large safety factor has been set.

CADMIUM (Cd). MCL is 0.005 mg/L or 5 μg/L. As far as is known, cadmium is biologically a nonessential element of high toxic potential. The health effects of long-term exposure in the United States appear to be from diet, cigarette smoking and seepage into the groundwater from industrial plants, especially wastewater. Cadmium is believed to be mutagenic but not carcinogenic.

CHROMIUM (Cr). MCL is 0.1 mg/L. Though chromium is considered an essential nutrient, it is toxic to humans at low concentrations. Chromium is involved in the body's use of blood sugar but excesses cause skin irritations and produce lung tumors when inhaled. Long-term exposure may cause skin and nasal ulcers. Chromium accumulates in the spleen, bones, kidney and liver. It occurs in some foods, in air (including cigarette smoke) and in some water supplies. The level of chromium that can be tolerated over a lifetime without adverse health effects is still undetermined.

LEAD (Pb). MCL is 0.015 mg/L. Exposure to lead in water, either brief or prolonged, can seriously injure health. Prolonged exposure to relatively small quantities (more than 0.05 mg per day) may affect health. Lead exposure occurs from air, food and water sources. All exposures are additive and lead accumulates in the bones which results in elevated lead levels in blood. Known effects range from subtle biochemical changes and reduced mental efficiency at low levels of exposure to severe neurological and toxic effects and even death at much higher levels.

Water may be contaminated by lead from rocks and soil. However, most of Kansas has little lead in these sources and most of the water's pH is above neutral, and is alkaline where lead is less soluble. There is little reason to expect lead above the MCL in water supplies. Most lead in water will be dissolved from lead pipe, solder, and brass plumbing fixtures.

MERCURY (Hg). MCL is 0.002 mg/L. Mercury is distributed throughout the environment as a result of industrial and agricultural applications. Large increases in concentrations above natural levels in water, soils and air may occur in localized areas, though significant mercury problems are rare in Kansas. Outside of occupational exposure, food (particularly fish), is typically the greatest contributor to total mercury intake. Poisoning is characterized by major changes in the brain, including loss of vision and hearing, intellectual deterioration, and even death.

SELENIUM (Se). MCL is 0.05 mg/L. There is considerable difficulty in determining the toxic level of selenium intake in humans because the diet contains an unknown variety of selenium compounds in varying mixtures. Signs of toxicity have been seen at an estimated intake of 0.7 to 7.0 mg per day. Possible health effects include growth inhibition; skin discoloration, dental and digestive problems, liver damage and psychological disorders. Some studies have raised concern over the possible carcinogenic properties of the element, but is not believed to be carcinogenic.

For further discussion of additional inorganic analysis for drinking water including inorganic heavy metals (antimony, asbestos, beryllium, copper, cyanide, nickel, silver, thallium, zinc, and copper) refer to *Understanding Your Water Test Report*, MF-912, K-State Research and Extension. For information and interpretation of organic chemicals and radioactivity in drinking water see publication *Organic Chemicals and Radionuclides in Drinking Water*, MF-1142.

COMMON MEASUREMENT UNITS AND CONVERSIONS

1 grain per gallon (gpg) = 17.1 mg/L

mg/L = milligrams per liter (parts per million)

μg/L = micrograms per liter (parts per billion)

1 gram = 1,000 milligrams (mg) = 1,000,000 micrograms (μg)

454 grams = 1 pound

1 liter = 1.05 quarts

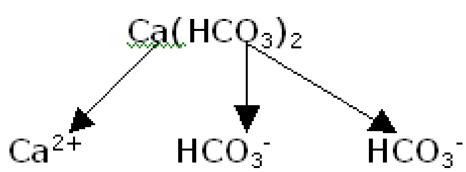
WATER STABILITY AND CORROSION CONTROL

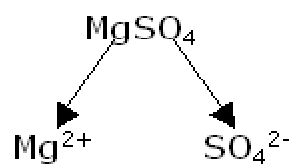
Few homeowners with private water supplies think about the stability of their water. Water stability is an important consideration in swimming pools and spas, as it affects water clarity and equipment maintenance. Private water systems can experience problems related to stability of the water, which lead to concerns related to personal health and aesthetics. Water stability is described as the ability to dissolve or deposit calcium carbonate ($CaCO_3$). Unstable water either deposits $CaCO_3$ as a film or scale inside pipes and fixtures, or it dissolves the scale and exposes metals in the system. Dissolving water is also called aggressive or corrosive.

Hard Water

Most well waters in Kansas are classified as hard or very hard due to the level of total dissolved solids (TDS), primarily the soluble ions of calcium and/or magnesium (Ca^{2+}, Mg^{2+}). The sources of these ions are certain common soluble salts:

1. Calcium Hydrogen Carbonate $Ca(HCO_3)_2$
2. Magnesium Hydrogen Carbonate $Mg(HCO_3)_2$
3. Calcium Sulphate. $CaSO_4$
4. Magnesium Sulphate $MgSO_4$





These compounds interfere with suds formation so that more soap or detergent is necessary to clean effectively. The calcium and magnesium ions react with soap making a curdy scum. Soap will form a lather when there are no calcium or magnesium ions in the water. Therefore extra soap is needed to form a lather in hard water. The extra soap removes the calcium and/or magnesium ions, softening the water.

Hard waters leave white mineral deposits (commonly called lime) when the water evaporates. Most (but not all) hard waters tend to deposit CaCO3 as a lining in pipes, tanks, and fixtures. As these deposits continue, the inside diameter of the pipe becomes smaller, lowering water pressure and delivery. Eventually such pipes and fixtures must be replaced to restore water pressure.

Some of the hardness can be removed by boiling; this is called temporary hardness and is caused by calcium hydrogen carbonate (also called calcium bicarbonate) and magnesium hydrogen carbonate.
Boiling causes these to change into insoluble calcium and magnesium carbonate, which settle out as scale or lime in kettles, boilers, and water heaters. This is the reaction:

$Ca(HCO_3)_2$ + Heat -> $CaCO_3 + H_2O + CO_2$ $Mg(HCO_3)_2$ + Heat -> $MgCO_3 + H_2O + CO_2$

Where: $CaCO_3$= calcium carbonate; $MgCO_3$= magnesium carbonate

Calcium carbonate and magnesium carbonate are insoluble and so do not release calcium or magnesium ions into the water – they do not cause hardness. Permanent hardness is not removed by boiling. It is caused by the presence of calcium sulphate and magnesium sulphate.

$CaSO_4$ + Heat -> $CaSO_4$ $MgSO_4$ + Heat -> $MgSO_4$

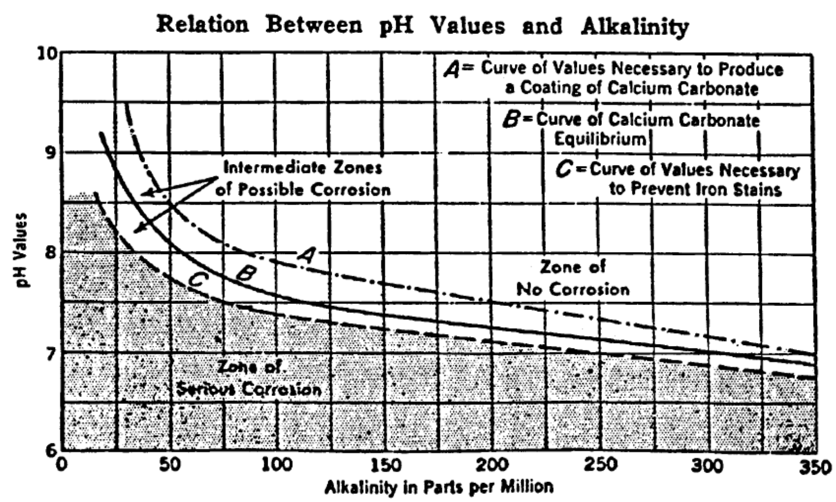
Soft Water

"Soft" water contains respectively fewer calcium and magnesium compounds and allows suds formation with smaller amounts of soap or detergent. This is an advantage when cleaning, bathing, and doing laundry, and is the usual reason for installing a water softener. If corrosive, soft water can dissolve any $CaCO_3$ lining, exposing the pipe. In the case of metal pipes and fixtures, heavy metals such as iron and lead are dissolved in the water, resulting in equipment failure, leaks, and unhealthy lead levels in the water. In times past, rainwater was caught and stored in a cistern for use in laundry and garden irrigation. Rainwater the product of Nature's distillation, is usually very soft, with very low TDS and virtually no calcium or magnesium, making it also corrosive.

Water Stability

There are several stability indices that calculate the water's ability to dissolve or deposit $CaCO_3$. Public water systems are required to evaluate their water's stability and to maintain a condition that allows for slight deposition as a protective liner in distribution. The Baylis Curve is a chart which shows the relationship between pH, total alkalinity, and water stability. It is simple to use and provides a reasonable indication of water stability; however water temperature is not taken into account. When water is heated (as with a household water heater), it can become more corrosive as temporary hardness precipitates out, lowering the alkalinity.

Figure I-15. Baylis Curve Showing Zones of Severe, Intermediate, and No Corrosion



Total alkalinity is not the same as hardness. It is the measure of all the alkaline material in the water and is really an indicator of the ability of the water to resist change in pH. Calcium (Ca^{2+}) and magnesium (Mg^{2+}) are primarily responsible for hardness. However in most Kansas well waters, alkalinity and hardness have similar values because the carbonates and bicarbonates responsible for total alkalinity are commonly in the form of calcium and magnesium carbonate or bicarbonate. Be aware that waters with high total alkalinity are not always hard, since the carbonates in the water can be in the form of sodium or potassium carbonate. This is the case in water softened by the ion exchange method where calcium is exchanged for sodium or potassium, leaving the carbonate levels unchanged.

How Does Water Stability Cause Problems

Depositing water creates problems with adequate supply over long periods of time. Fixtures tend to clog and aerator screens can literally grow closed with lime deposits. These are not human health problems, but cause expensive repairs.

Corrosive or dissolving water causes problems for human health and aesthetics. Of concern in plumbing is the use of leaded solder on copper piping in homes built before 1986. Brass items and fixtures made before that date also contained lead. Corrosive water can leach lead from any exposed solder and brass components, creating a danger to health. Orange (rust) staining of laundry and fixtures is usually related to iron dissolved in the water.

Solving the Problem

The first step is determining water stability. A swimming pool test kit will include both pH and total alkalinity. The results of those two tests can be plotted on the Baylis curve. It is worthwhile to test and compare results for:

- hot water
- cold water
- untreated/unsoftened water
- treated/softened water

If the results are inconclusive, a more precise analysis can be calculated using the Langlier Saturation Index, which requires these water tests: pH, temperature, total dissolved solids, total alkalinity, and calcium. The Saturation Index (SI) is typically either negative or positive and rarely zero. A SI of zero indicates that the water is "balanced" and is likely not scale forming. A negative SI suggests that the water would be undersaturated and potentially corrosive. If the SI lies between -1.0 and +1.0, treatment is usually not needed. Here are two websites with automatic calculators for the Langelier Saturation Index:

www.edstrom.com/Resources.cfm?doc_id=161

www.corrosion-doctors.org/NaturalWaters/Langelier.htm

If the water is determined to be depositing (a positive SI), a water softener can be installed. The most common water softener exchanges calcium ions for sodium and uses brine (salt) to recharge. If sodium in the diet is a concern or the taste of softened water is offensive, it is a simple matter to install a separate line carrying untreated cold water to the kitchen sink for cooking and drinking purposes. If the water is softened to zero hardness, there is the potential to create a dissolving (negative SI) water. It is a good idea to recheck the water's stability after installing a softener and make adjustments as needed.

If the water is determined to be dissolving (corrosive), raising the pH is usually the solution. This can be accomplished by feeding a basic solution (soda ash) or passing the water through a neutralizing filter. In Kansas, ground waters are commonly basic (high pH), but shallow wells drawing from surface water sources may exhibit lower pH, and be corrosive.

Appendix C. KDHE Private Well Water Quality Screening Results Interpretation

Parameter	Acceptable+ for consumption no evidence of risk	Limited acceptability for consumption may present risk (1)	Unacceptable for consumption (2)
Total Coliform			XXXXXXXXXXXXXX
Fecal Coliform		XXXXXXXXXXXXXXX	
E. Coli		XXXXXXXXXXXXXXX	

(1) The presence of total coliform bacteria in your water supply suggests structural problems with your well, household plumbing, or the presence of nearby sources of or points of entry by bacteria. Follow the steps on the continuation of this report to correct the contamination and improve the structural integrity of the well.

(2) The presence of fecal coliform or *E. coli* bacteria indicates that domestic sewage or animal waste is entering the well or household plumbing. Water should not be consumed until the problem is corrected. Follow the steps on the other side of this report to correct the contamination and improve the structural integrity of the well.

Parameter	Acceptable+ for consumption ≤ 10 mg/L (ppm)	Limited acceptability for consumption > 10 ≤ 20 mg/L (ppm) (1)	Unacceptable for consumption > 20 mg/L (ppm) (2)
Nitrate (as N)			

(1) **Water with nitrate levels in this range should not be consumed by infants under one year of age or pregnant or lactating women.** An alternate known safe source of water for drinking and cooking should be obtained for pregnant or lactating women and for children under one year of age. Although the EPA recommends that all drinking water be below 10 mg/L, there is no evidence that consumption of water with nitrate levels in this range, and which is otherwise uncontaminated, poses an unreasonable risk to health for non-pregnant and non-lactating adults and children over one year of age. A decision to continue consumption of water with nitrates in this range is an individual decision to be made in consultation with one's physician.

(2) An alternate source of safe water for drinking and cooking should be obtained until the problem is corrected and the level is below 20 mg/L.

Parameter	Acceptable+ for consumption < 15 µg/L (ppb)	Unacceptable for consumption ≥ 15 µg/L (ppb) (1)
Lead		

(1) An alternate source of water for drinking and cooking should be obtained until and unless corrective actions have effectively reduced the level of lead below 15 µg/L (ppb). Plumbing containing lead is usually the cause of lead contamination. Contact your health department for assistance in locating the specific source(s).

+ Acceptability for consumption or other use is determined on the basis of each parameter individually. Acceptability on the basis of any single parameter does not guarantee that other parameters (tested or untested) are within an acceptable range. Other factors such as poor siting or poor construction may cause a well to be vulnerable to contamination even if all laboratory parameters are within acceptable range on a single test.

See continuation of Appendix C for recommended corrective actions and procedures.

Appendix C (continued). Recommended Corrective Actions for Wells

☞ **If the water is *acceptable* for all parameters tested, do steps 1 through 7 below:**

1. Continue to have water screened for listed parameters at least once a year.
2. Keep the area within a radius of at least 400 feet of the well free of potential sources of contamination including chemicals (gasoline, oil, cleaning fluids, pesticides, fertilizers), animal pens, or septic system components.
3. Check and maintain the site of the well so surface water runoff does not drain to or pool within 50 feet of the well site.
4. Check and maintain the construction of the well so openings do not exist which would let insects, animals, or surface runoff enter the well.
5. Do not mix chemicals or rinse containers and application equipment within 400 feet, or uphill from the well, and always use a backflow prevention device to prevent back siphoning.
6. Confirm that no cross-connections exist between the well and any potential source of contamination.
7. Do annual shock chlorination as part of regular well maintenance program.

☞ **If water has *limited acceptability* for any test, in addition to steps 1 – 7 above do steps 8 through 16:**

8. Have the water tested in a certified laboratory for the specific parameters indicated in the category.
9. Contact the County Environment or Health Department, county Extension Office, or KDHE District Office for information on correcting problems related to your specific results.
10. Inspect the area around the well (within 400 feet) for any potential sources of contamination related to your specific results.
11. Inspect the construction of the well to identify any openings which could allow insects, animals, surface water or shallow subsurface groundwater to enter the well directly.
12. Review household plumbing for potential defects or opportunities for cross-connections.
13. Contact the County Environment or Health Department, county Extension Office, or KDHE District Office for guidance and correct any contaminant source or well construction problem(s) noted in 10 through 12 above.
14. If the well tested positive for any bacteria categories, shock chlorinate the well (see Appendix A or K-State Research and Extension publication *Shock Chlorination for Private Water Systems*, MF-911 for instructions). Shock chlorination **will not correct** high lead or nitrate.
15. Retest the water for specific parameters noted after waiting for at least 7 days and after no chlorine is detected.
16. If the water tests are "acceptable", perform the basic water screening tests quarterly for one year, then follow steps 1 through 7, above, on a regular basis.

☞ **If the water is *unacceptable for consumption*, in addition to steps 1-16, also do steps 17 through 19:**

17. Do not use the water for drinking and food preparation until water meets drinking water standards. Obtain an alternate safe water supply (i.e., public water supply, bottled water) for drinking purposes until the problems are corrected.
18. Follow steps 8 through 16 above.
19. After the quality problems are corrected, restore the water system to full use and annually follow steps 1 through 7.

Prepared by the Kansas Department of Health and Environment, September 1997, Revised 2/05

Appx. D. EVALUATION OF TASTE AND ODOR COMPLAINTS (trouble shooting guide)

Description of Taste / Odor: ____
____
____
Source of water: ____

	Circle appropriate parameter			
1. Odor predominates or is only in hot water – suspect water heater[1]	Yes	No	Psbl	NA
2. Chemical(s) storage in pump house or within 200 feet	Yes	No	Psbl	NA
3. Underground petroleum storage or pipelines	Yes	No	Psbl	NA
4. Frost-proof hydrant used to fill chemical spray tank	Yes	No	Psbl	NA
5. Automatic livestock water devices (back-siphonage)	Yes	No	Psbl	NA
6. Other back-siphonage potential ________________	Yes	No	Psbl	NA
7. Foundations treated for termite control within 50 feet of well	Yes	No	Psbl	NA
8. In-line water treatment equipment (softener/filter/other)	Yes	No	Psbl	NA
9. Well is large diameter (greater than 8 inches diameter)[2]	Yes	No	Psbl	NA
10. Abandoned well/cistern/cesspool within 400 ft. of well	Yes	No	Psbl	NA
11. A slimy growth in toilet tank – suspect iron bacteria	Yes	No	Psbl	NA
12. Brownish or reddish staining of plumbing fixtures – suspect iron	Yes	No	Psbl	NA
13. Black staining of plumbing fixtures – suspect manganese	Yes	No	Psbl	NA
14. Oil or iridescence observed on surface[3]	Yes	No	Psbl	NA
15. Groundwater less than 20 feet deep/Spring-like water source	Yes	No	Psbl	NA
16. Well improperly sealed (not water-tight, electrical seal)	Yes	No	Psbl	NA
17. Contamination of well by near-by potential sources	Yes	No	Psbl	NA
Frostproof hydrant(s)	Yes	No	Psbl	NA
Well pit / Sump pump	Yes	No	Psbl	NA
Air-conditioner discharge	Yes	No	Psbl	NA
Roof or surfaced areas	Yes	No	Psbl	NA
Water softener recharge/effluent discharge	Yes	No	Psbl	NA
18. Corrosive or highly mineralized water (evaluate Langlier index, see discussion in Appendix B):				
Total dissolved solids (TDS): greater than 1,000 mg/L	Yes	No	Psbl	NA
Total hardness: greater than 700 mg/L	Yes	No	Psbl	NA
Chlorides: greater than 250 mg/L	Yes	No	Psbl	NA
Sulfates: greater than 500 mg/L	Yes	No	Psbl	NA
Iron: greater than 0.3 mg/L	Yes	No	Psbl	NA
Manganese: greater than 0.05 mg/L	Yes	No	Psbl	NA
Other: ______________________________	Yes	No	Psbl	NA
19. Individual detecting problem has recently changed medication?	Yes	No	Psbl	NA

PUT COMMENTS AND OTHER INFORMATION ON A SEPARATE SHEET

[1] Suspect magnesium anodes in water heater. Change anode to aluminum. Removing the anode will shorten the wh life.
[2] Well may contain rotting wood, animal, debris, or other contaminants.
[3] Suspect leak from submersible pump or contamination of well.